THE ROLE OF INSTITUTIONS FOR THE PATH DEPENDENT DEVELOPMENT OF THE WIND ENERGY INDUSTRY IN GERMANY AND BRITAIN

CAMILLA M. CHLEBNA

A thesis submitted in partial fulfilment of the requirements for the award of
Doctor of Philosophy at Oxford Brookes University

January 2017

In memoriam Martin Alder (†2016)

Dedicated to my parents Franziska and Hans Chlebna

Abstract

The key argument of this thesis is that institutional settings have a crucial impact on path dependent economic development. It is also argued that both formal and informal institutions play an important role. The contribution to knowledge lies in the unique combination of a path dependency perspective with an institutional focus and the proposition of two frameworks to examine the relationships between the concepts. It is evidence for the valuable contribution that strongly qualitative approaches in studies in evolutionary economic geography can make.

A multi-level perspective is applied in two frameworks. Three key levels are examined: The civil society, where transitional new pathways originate, the path dependent industrial landscape which new technological pathways seek to reach, and the institutions which need to support these new technological pathways so they can develop. It is argued through the conceptual framework that the institutional arrangements act as a filter on agents' perceptions and that therefore different institutional constellations in different regions or countries are one important cause of divergent economic development. The analysis framework proposes a role for both informal and formal institutional arrangements, where informal institutions have an important impact on whether and how the formal institutional arrangements are co-evolved by agents because of their immediate effect on their perceptions and behaviour.

These frameworks were tested by applying them to the case of the path dependent development of the wind energy industry in Germany and Britain. 32 semi-structured interviews with industry experts followed a pilot study of four interviews with academics. A good spread across the two countries and across perspectives was achieved.

It was found that in Germany the strength of the anti-nuclear sentiment in combination with the federal structure allowed for new ideas about energy generation to get a foothold amongst policymakers. In contrast the relatively closed, hierarchical formal institutional structure in Britain in combination with a lack of a comparable strength of sentiment amongst society in general hindered similar institutional co-evolution and institutional hysteresis continued.

Acknowledgements

This is an opportunity to reflect on a wonderful 3.5 years at Oxford Brookes University and on almost 8 years in Oxford. Many people have supported me on this academic journey and deserve to be mentioned here.

First of all, and perhaps most importantly, I would like to thank my respondents who have helped me by giving their time and often lending me additional resources and advising me well beyond the interview. I was blessed to be allowed to tap into the welcoming wind and renewable energy community in Britain and Germany.

Another extremely helpful group of people were my proof readers: William, my housemate, Carol, my colleague, and Kevin, my boss. All of you have done an excellent job in a short time frame and have provided useful, critical comments leading to important improvements.

My aunties have contributed to the timely completion of this work by supporting me both emotionally and financially and I am very grateful for this. Both my friends Kathi and Katja have been truly great friends, advisors, and listeners and will hopefully remain a part of my life forever. Some of the most outstanding support I have had from my terrific housemates, who have been my rock throughout the process. Not least when they thought I had got 'stuck on the climbing wall' and I had actually fallen off and sustained a serious injury, they were there for me well beyond what a housemate may be expected to do. From sharing their food with me to washing my hair they did not hesitate to support me. Never in my life will I forget what you have done for me!

The Department of Planning and the wider research community at Oxford Brookes University are exceptional. We enjoy outstanding resources and excellent staff. Their friendliness and warmth makes this a special place. Prof Sue Brownill in her role as research tutor was a reliable and approachable source of advice. My second supervisor Dr Dave Valler has been there for my often emotional self throughout this process. Finally, my Director of Studies Prof James Simmie guided me excellently. He understood when to apply pressure to push me towards better results and was there to support me in challenging periods. I thank you all for the opportunity to learn from you.

I do not think I could have completed this thesis without the strong support and unconditional love of my parents who were there for me despite the geographical distance whenever I needed them. This is for you.

Table of Contents

List of Figures

List of Tables

List of Illustrations

1 Introduction

1.1 INTRODUCTION

This thesis seeks to make a contribution to studies of transitional technological change within economic geography. It puts forward frameworks for the investigation of the relationship between path dependent economic development and institutions and for the role of different types of institutions for institutional co-evolution with technological development and changing circumstances. These frameworks are tested using the case of the divergent development of the wind energy industry in Britain and Germany.

This first chapter is structured in two main parts. One introduces to the subject and its context whilst the other is focused on the key elements of the study as such. The first part introduces the wider context to the subject of transitional technological change in the face of the grand societal challenge of climate change and to the case of the wind energy industry in Germany in Britain. It explains the most important global and European climate policies that formed the context for this industry to develop. It then provides some introductory comments on the national policy context and a short summary of the development of the use of wind for energy generation.

The second part of the chapter presents the most important elements of the study. It introduces the aim and objectives, the hypotheses and the research questions. The research strategy consisting of the scope of this research, the particular approach used, and the methods applied to investigate the cases is laid out. Finally the main theoretical arguments are summarised and the structure of the thesis is explained.

1.2 BACKGROUND

This thesis is written with the intention of making a contribution to the field of evolutionary economic geography. Within this field it is primarily concerned with the study of technological transition in the face of grand societal challenges and that of climate change in particular. Two frameworks have been developed to help investigate the uneven development of a transitional industry between two areas. These have been tested and further developed by applying them to a case study of the development of the wind energy industry in Germany and Britain.

The wind energy industry has seen rapid development in the last thirty years. It serves as a good case study because of its relatively recent emergence, which means that key agents are still available to speak to. For a considerable period Germany has been in a leading position, both in techno-industrial development and in the diffusion of wind energy. Whilst there were innovative companies at the forefront of technology in the early years in Britain, there was no comparable development of this industry. With relatively similar inventive activity, but divergent industrial development and very different institutional settings, the two countries therefore constitute good cases for a study of the role of institutions for divergent economic outcomes.

Wind energy has been a key part of Germany's rhetoric of the 'Energiewende', or energy transition. It seems that policymakers in Germany understood the potential of this technology early on, decided to support it, and succeeded in fostering a sustainable industry that will last into the future. With a slight delay, Britain too, has seen a highly dynamic diffusion of wind energy technology, especially in the deployment of offshore wind farms. It appears to have missed the opportunity to create a wind energy industry, however, despite the existence of companies at the forefront of the technology in the early 1980s.

All of the offshore turbines installed in British waters are built and developed by foreign directed companies with significant support by the British government. Despite some investment in local production sites by foreign (mostly German) manufacturers and a number of British companies in the supply chain Britain will not succeed in reaping the socio-economic benefits of this by now global transitional development in the same way that Germany did. An opportunity lost despite historically strong engineering competencies and the best wind resource of any European country.

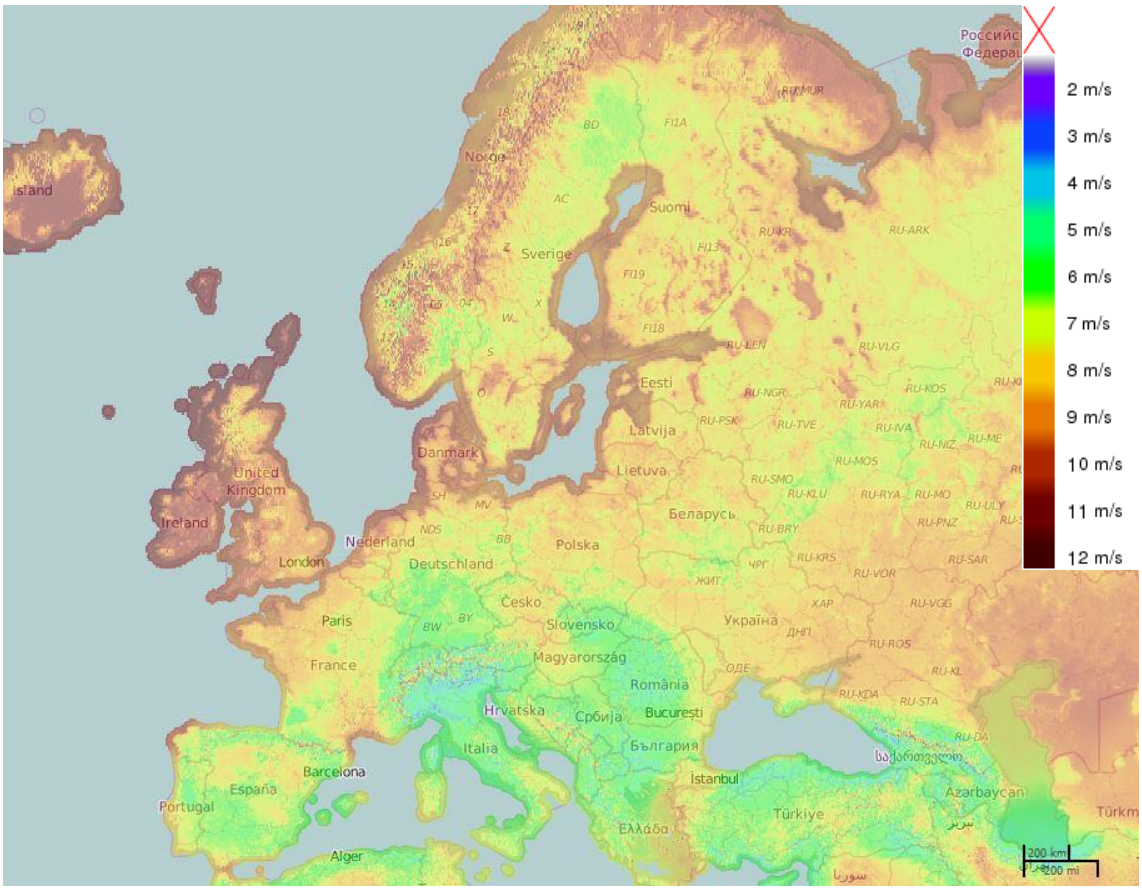


Illustration 1: Average wind speed at 200m height in Europe [resolution 1km, onshore and 30km offshore] (IRENA, 2016)

The mere resource, represented at average wind speed at 200m height in the map is about average overall in Germany but exceptional for Europe in Britain. Despite this, Germany has embarked on the project of building an industry around harvesting this resource much earlier and arguably with greater enthusiasm than Britain has. This implies that, whilst topography and resource availability form an important context, other reasons, rooted in society, determine which technologies gain support and succeed.

This study seeks to uncover the dynamics of the differences in the development of the wind energy industry in the two countries beyond statistics. It is historical in character as it looks back as far as the post-war period to understand the reasons for the divergent development in both countries. Its quantitative element illustrates the rise of the wind energy industry in each country and some of the socio-economic effects whilst the qualitative element explores the motivations and restrictions that agents faced which led to the development of a lively, varied industry dominated by SMEs in Germany and an industry dominated by large, foreign directed companies in Britain. This will deepen our

understanding of the multitude of factors behind uneven economic development in different areas.

The following section gives a rough overview of the policy context, starting from the global and European context and closing in on the national policy context. This is followed by a short summary of the development of the wind energy technology and industry.

1.2.1 Global and European Policy Context

The broader context for this study is the increasingly accepted necessity to shift away from fossil fuels for energy generation in the face of climate change.

Whilst there were some concerns about fuel scarcity immediately after World War II in most European countries throughout the 1950s and 1960s, cheap fuel, oil in particular, appeared to last forever. Technological and as a consequence economic development was therefore progressing at great speed. Most countries first awoke to their dependency on the oil producing countries when a conflict between OPEC (Organisation of the Petrolium Exporting Countries – mostly dominated by Arab countries) and the USA who had supported Israel in the Yom Kippur War led to an oil embargo and thus an energy crisis in 1973. When the second energy crisis hit in 1979 the danger of dependency on potentially volatile countries became even clearer (Ohlhorst, 2008).

A number of incidents at nuclear plants, including that at Three Mile Island in the USA in 1979 and that at Chernobyl in Ukraine in 1986, galvanised people to organise as part of a global anti-nuclear movement which would join forces with the existing environmental and peace movements (Musgrove, 2010; Vasi, 2011; Sine & Lee, 2009). From the late 1970s there was increasing recognition of environmental destruction through human activities internationally. This led to the formation of the Brundtland Commission in 1983, who released the much cited report 'Our Common Future' in 1987. This provided one of the first definitions of 'sustainable development', which is still widely used. The emphasis was put on inter- and intra-generational equity and the three pillars of 'environmental, economic, and social sustainability' were established (World Commission on Environment and Development, 1987).

An important step towards the international recognition of climate change was the formation of the Intergovernmental Panel of Climate Change (IPCC), a scientific body under the auspices of the UN in 1988. Scientists from across the world contribute to its assessment reports, the first of which was published in 1990 (IPCC, 2017). The United

Nations Framework Convention on Climate Change was established in 1992 and has been joined by 195 countries. It focuses on four key areas (UNFCCC secretariat, 2014):

1. Adaptation to climate change.
2. Financial aid to enable action on mitigation and adaptation to climate change.
3. Mitigation of greenhouse gas emissions (i.e. reduction).
4. Technological development and transfer to allow green development.

The IPCC's second assessment report from 1995 is widely accepted to constitute the first definitive statement that humans are responsible for global warming. As a consequence 37 industrialised countries agreed to commit to cuts of emissions through what has become known as the Kyoto protocol (result of the UNFCC meeting in Kyoto in 1997). It was agreed that emissions were to be reduced by 5% of 1990 levels between 2008 and 2012. This was achieved but was found to be insufficient. When a second period from 2013 to 2020 was agreed upon, not all initial participants signed but the European Union did. The EU has committed itself to three key targets for 2020 known as the 20-20-20 targets (Committee on Climate Change, 2017):

1. To reduce emissions by 20% on 1990 levels.
2. To provide 20% of its total energy from renewables.
3. To increase energy efficiency by 20% from 2007 levels.

Most recently, during the course of writing this thesis, the climate conference in Paris (COP21) in December 2015 produced a seminal agreement amongst 195 countries to legally commit to action on climate change. The shared goal is to limit the increase in global temperature to well below 2°C above pre-industrial levels but to aim for an increase of not more than 1.5°C. Importantly, a regular stocktake and mutual assistance has also been agreed on.

These are some of the most important global and European steps towards a policy environment that recognises climate change as one of the key grand societal challenges of our time. The following section will introduce some of the most important national policy steps taken. A more detailed, critical review of national policy measures and their impact on the wind energy industry will follow in chapter 4, a historical review from a path dependency perspective.

1.2.2 National Policy

1.2.2.1 Britain

The United Kingdom has signed up to the Kyoto Protocol as explained above since 1995. Before that there has only been limited acknowledgement of the threats of climate change by policymakers. The government under Margaret Thatcher introduced the Non-Fossil Fuel Obligation in 1989 in support of alternative means of energy generation to coal. Whilst on the surface, and certainly represented in the name of the legislation, this might be interpreted as a measure to tackle climate change this is known to have been a measure to support the nuclear industry in order to privatise it. Contracts were handed out to energy schemes in a number of auction rounds throughout the 1990s. The system's competitive set-up, complexity, and irregularity of auctions led to the exclusion of smaller schemes and a bias towards large companies. A small number of renewable energy projects did get developed, however (Lauber, 2012; Musgrove, 2010).

The UK government changed in 1997 from Conservative to a Labour government under Tony Blair. The Labour party was keen to prove its environmental credentials in the light of increasing global recognition of the threat of climate change (Kyoto protocol, see above) and promised more action on climate policy. Following lengthy consultations, the Renewables Obligation (RO) was eventually introduced in 2002. The requirement was put on electricity suppliers that 3% of their supplied electricity needed to come from a renewable source. This was to rise up to 10.4% until 2010. Each unit of generation was given a renewable obligation certificate. These certificates were tradable through which they acquired a market value. Although it led to significant development in the renewables sector, the RO favoured the incumbent companies and did not encourage new entrants (Lauber, 2012; Geels et al., 2014; Mitchell, 2008).

The early 2000s saw the recognition of the country's vast offshore potential leading to a highly supportive policy environment and the completion of some of Europe's largest offshore wind projects. At the point of writing Britain is the world leader in offshore development. In 2006 Lord Stern published an influential economic review of measures of climate change mitigation and came to the conclusion that it was more economical (~1% of GDP) to curb global warming immediately than to deal with the effects later (~20% of GDP) (Stern, 2007). The Energy White Paper of 2007 recognised the importance of differentiation between different kinds of technologies and further reinforced extended use of biomass and offshore wind energy (Department of Trade and Industry, 2007). In line

with global agreements the 2008 Climate Change Act committed the UK to cut Greenhouse Gas emissions to 80% of 1990 levels by 2050. It also introduced carbon budgets which restrict the amount of greenhouse gas emitted over a period of five years each. The climate change committee, an advisory body to the government has been set up and a national adaptation plan has been put in place which strategically assesses the risks from climate change to the country and requires the government to address them (Committee on Climate Change, 2017). Finally in 2010 the UK also introduced a feed-in tariff, similar to the German Einspeisetarif, but restricted it to projects under 5MW (Lauber, 2012).

1.2.2.2 Germany

Between 1987 and 1995 a 'committee for the provision for the protection of earth's atmosphere' (Enquetekommission zur Vorsorge zum Schutz der Erdatmosphäre) was in place in Germany. This was a committee including politicians from across the political landscape and independent experts, which assessed potential threats by climate change to Germany and made suggestions of potential measures. One such proposed measure was the support of renewable energy technologies by the national government. Building on a range of smaller schemes on the subnational level such support on the national level was eventually put in place in the shape of the electricity feed in law (StrEG – Stromeinspeisegesetz) in 1990. This was primarily the result of pressure from politicians on the regional level who sought support for hydro (in the south of the country) and wind (in the north of the country) schemes to ensure their survival. The Conservative-Liberal (CDU/CSU – FDP) government of the time is thought to have under-estimated the wide reaching consequences this would have (Jacobsson & Lauber, 2006; Lauber, 2012; Rave & Richter, 2008; Ohlhorst, 2008).

A change of government to a red-green coalition (SPD – Greens) led to the initiation of a program of 'ecological renewal' with an exit from nuclear and climate protection as key policies. The ministry of the economy was asked to prepare an overhaul of the feed-in law in support of renewable energy. Delays to the presentation of a draft were considered unacceptable and a group of parliamentarians demanded that they were to draft the renewed legislation. This was granted and in 2000 the Renewable Energy Law was put in place which guaranteed preferred access to the grid for renewable energy generation schemes as well as fixed tariffs over 20 years and a gradual decrease in support as the technology matures. It is seen as the most influential legislative change for the wind energy industry.

Elections in 2002 confirmed the coalition government and increased the influence of the Green party, which gained power over the ministry of the environment as a result. Greenhouse gas emission reduction targets became more ambitious and were set at 40% by 2020. In 2010 a longer term strategy was introduced which includes the transition towards renewable energy as main source of electricity. Following the nuclear incident at Fukushima, Japan, in 2011, a complete exit from nuclear power by 2022 (which the newly elected Conservative-Liberal government had waivered on) was decided upon and integrated into the climate policy. This became known as 'Energiewende' and gained vanguard status in climate policy across the world (Böhler-Bädeker & Mersmann, 2013; Szarka, 2007).

The international agreements and targets as well as the national policy steps introduced above form an important part of the environment against which the wind energy industry has developed. The following section will give a short introduction to the development of the use of wind for energy generation and the creation of the industry. Further detail is given in chapter 4, the historical review of the development of the wind energy industry from a path dependency perspective, and chapter 5, which focuses on the role of institutions for the development of this industry in Britain and Germany.

1.2.3 Wind Power – A Short Introduction

The harvest of wind for running agrarian machinery has a long tradition across Europe and wind mills were wide spread in the late 19th century. They were used for irrigation, pumping and grain milling. The first patent for the use of a windmill for the generation of electricity was granted to Prof James Blyth in Scotland in 1891 (Gipe, 1995). His traditional design was very common but its use declined in the early 20th century due to its inferiority to steam technology.

In Denmark, arguably the birth country of the modern wind turbine technology and industry, fuel scarcity after World War II as well as a struggle to provide remote areas with electricity drove innovative activity in the field of wind energy technology. The government was convinced by wind pioneer Johannes Juul to invest in research on this technology. This resulted in the creation of the Gedser turbine, one of the first three bladed models, which is considered the forerunner to the modern wind turbine (Gipe, 1995; Musgrove, 2010).

In the UK, after World War II, the electricity industry had been nationalised and in the 1950s a National Wind Power Committee, co-ordinated by the Electrical Research

Association, was set up to carry out a survey of suitable sites and to test prototypes. Three prototypes were tested, all of which eventually failed and government funding ceased (Musgrove, 2010).

The advent of the microprocessor in the early 1970s and its increase in capacity and applications in technology throughout the 1970s and 1980s had a significant impact on wind turbine technology. This meant that turbines could be operated automatically or remotely without the need for permanent attendance – a significant factor in the cost-effectiveness of energy generation through wind turbines (European Wind Energy Association, 2009).

In line with many other European countries and the US, Germany also focused on the development of large scale machines in the 1970s, most notably the infamous GROWIAN (3MW expected output). Although the project failed at great cost and embarrassment, it was ground-breaking and did inspire later large scale projects. Efforts in Denmark are remarkable in that there were a number of dispersed but well connected groups of engineers who shared an interest in the future of the energy supply and in wind energy beyond government funded large scale projects. One was a group of teachers in Tvind who, together with their students, created a large (1MW) three bladed turbine from recycled materials, which has been running with no major problems since 1975 and generates electricity for the local school and facilities (Gipe, 1995; Musgrove, 2010; Garud & Karnoe, 2003).

Between 1980 and 1995, a combination of policy and tax incentives created niche conditions for wind energy in California, USA. The first commercial wind farm of 20 turbines was erected in New Hampshire in 1980 and initiated the Californian wind boom. Many of the constructed wind turbines were of low quality and created a bad reputation for the industry. The boom did, however, benefit the Danish manufacturers of high-end products. By that time the three bladed ('Danish') design was understood to be the most successful in output, cost efficiency, and acceptance and had conquered the market (European Wind Energy Association, 2009; Simmie, 2012).

In Germany, apart from the failed investment in large scale turbine development, there were a number of public investment initiatives supporting smaller scale efforts both on the national as well as on the subnational level. This is believed to be the basis that much of today's wind energy industry in Germany has been built on (Ohlhorst, 2008).

At the same time a small number of companies in Britain were also producing wind turbines of excellent, competitive quality. These were primarily construction consortia and individual inventors did not have any access to finance in the same way that their German and Danish counterparts did. So when the companies encountered problems and the government funding ran out and was not renewed, they lost interest in any further development of this strand of their business (Musgrove, 2010). Only one of these original businesses survives until today (as RES Ltd) but this is due to a reorientation towards development of renewable energy schemes rather than turbine production.

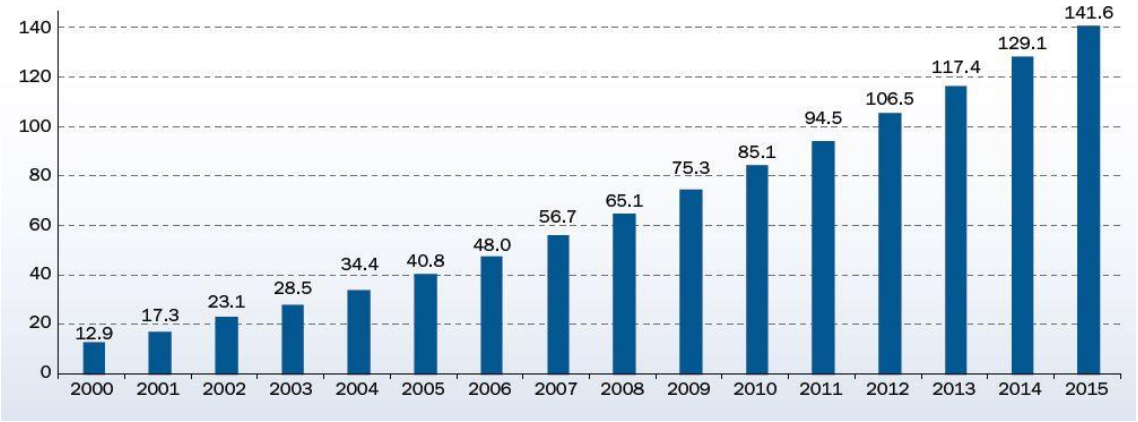


Figure 1: Cumulative wind power installed in the EU [GW], (European Wind Energy Association, 2016)

The figure above shows the cumulative wind power installed in the European Union between 2000 and 2015. It becomes clear from this graph that wind power is playing an increasingly strong role in the capacity mix. Germany has the most installed cumulative wind power capacity with a total of 44.9 GW, Spain is second with 23 GW and the United Kingdom is third with 13.6 GW, due to its rapid development of offshore wind schemes in recent years. The European Wind Energy Association estimates that with the current installed wind power capacity [2015] in an average wind year 11.4 % of the EU's total electricity consumption can be covered (European Wind Energy Association, 2016).

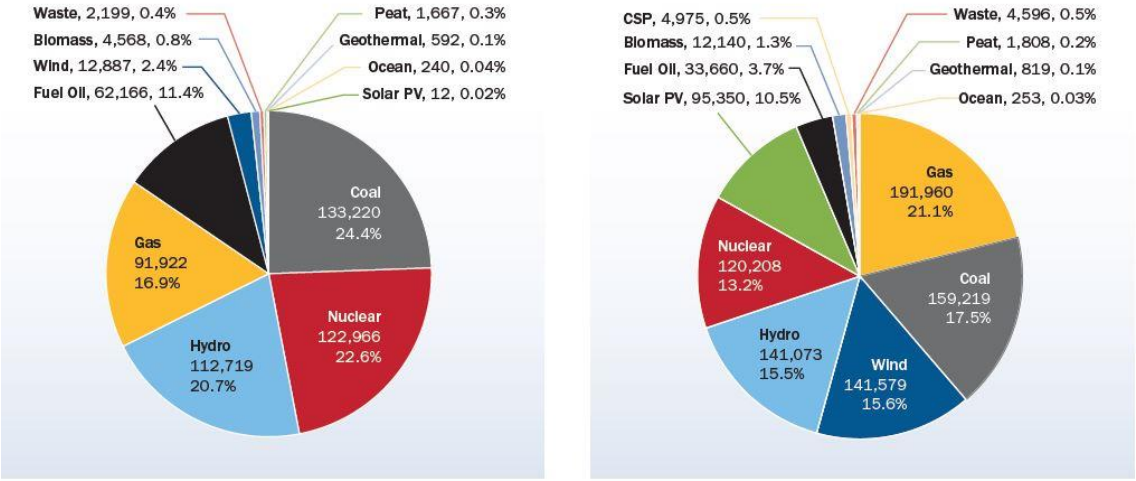


Figure 2: Power mix in 2000 (left) and 2015 (right), (European Wind Energy Association, 2016)

The two figures show the change in the power mix in the European Union in terms of installed capacity between 2000 (left) and 2015 (right). These two graphs make the remarkable development that wind has undergone in this period apparent and illustrate the shift it causes in the power mix. In just 15 years wind has grown from 2.4 % of the total energy mix in 2000 to a sizable contribution of 15.6% in 2015, overtaking nuclear (13.2%) and hydro (15.5%) and coming close to the share of coal (17.5%). Solar PV also constitutes a respectable 10.5% of the power mix in 2015. Renewables overall went from 24% in 2000 to 44% in 2015 (European Wind Energy Association, 2016).

This introductory chapter so far has provided some background on the wider relevance of this study, starting from the global and European policy context and closing in on the national policy context and the development of the use of wind for energy generation itself. The second part of this introductory chapter will focus on the mechanics of the study as such by introducing its objectives, the hypotheses investigated, and the key theoretical arguments followed by a summary of the research strategy.

1.3 RESEARCH AIM AND OBJECTIVES

Following initial research about the wider background as presented above, an aim and objectives were developed to structure the theory development and fieldwork. The overarching question to this thesis is

Why did the wind energy industry develop earlier and to a greater extent in Germany than in Britain?

The development of the wind energy industry in Britain and Germany diverged significantly. Whilst a vivid wind energy sector and a turbine manufacturing industry have thrived in Germany, no turbine manufacturer and a much less diverse wind energy sector remain in Britain.

1.3.1 Aim

In the initial stages of this study an aim has been formulated, **to investigate the uneven development of the wind energy sector in Germany and Britain with specific regard of the role of institutions.**

It is argued that institutions have a key impact on the divergence in development between Britain and Germany and that therefore they should be the focus of this study.

1.3.2 Objectives

To structure the research a set of seven objectives were formulated. The primary objective of this study was to create a **conceptual framework** in order to illustrate the role of institutions in the ascension of the wind energy technology into a path dependent economic landscape. This was to be used to develop an appropriate **methodology** to gather and analyse information about this industrial development. A **pilot study** was to be carried out to improve understanding and to refine the methodology with a view to a main fieldwork period. This main fieldwork was to consist of both a **quantitative** and a **qualitative element** where information from the latter was to explain observations from the former. The **analysis** of this information was intended to lead to an **improved framework** to compare the development of a transitional industry between countries or regions.

1.4 HYPOTHESES

The following two hypotheses were formulated in response of the overarching question. These hypotheses guided the formation of the conceptual framework and the research questions, which are presented further below.

Why did the wind energy industry develop earlier and to a greater extent in Germany than in Britain?

1.4.1 Hypothesis I

Whilst the economic landscape naturally evolves in a path-dependent manner, institutions crucially impact on industrial development in one area over another because they filter how agents perceive technological development and changing circumstances and therefore either co-evolve formal institutional arrangements in support of new pathways or not.

1.4.2 Hypothesis II

a) Informal institutions can provide access channels for new ideas leading to institutional co-evolution because they influence agents' ways of thinking and behaviour and therefore impact on the ongoing process of evaluation of institutions by agents.
b) The formal institutional arrangements equally impact on the ongoing process of evaluation of institutions by agents because they influence agents' ways of thinking and behaviour. If they are too rigid and closed, new ideas are prevented from getting a foothold and institutional hysteresis continues. In contrast, if they are open, new ideas can get established and the institutions are likely to co-evolve with technological development and changing circumstances.

1.5 RESEARCH QUESTIONS

The following research questions were derived from the hypotheses above:

1. In what way did civil society agents and incumbent firms seek to influence the institutional framework in Britain/Germany? Why were they more/less successful than their British/German counterparts?
2. What was the key factor for the formation of more or less supportive institutional arrangements in either case country? To what extent did

institutional inter-dependency between different scales and different types of institutions play a role?

3. How did new ideas in the realm of informal institutions impact on the perception of technological trajectories and changing circumstances by agents and in particular by agents within organisational forms of institutions?
4. Did the formal institutional arrangements restrict agents in their thinking and acting, in particular those within organisational forms of institutions? Did the formal institutional arrangements allow for new ideas to form amongst agents and in particular those within organisational forms of institutions?

1.6 RESEARCH STRATEGY

Whilst the sections above referred to 'what' was to be investigated in this study, the section below explains 'how' it was investigated. A short introduction to the overall research strategy and the methods applied is given.

1.6.1 Scope of the Research

This section gives information about the scope of the research which means it explains what is and what is not the focus of this study.

This is a study in economic geography on the role of institutional constellations for the development of transitional industries. It does not seek to explain technological development through technology itself, nor does it seek to justify the use of one technology over another. The benefit of the use of renewable energy technologies and wind energy technology is accepted as given and is not debated as part of this study.

The main focus of this study lies on the qualitative research element. The quantitative element serves to illustrate the divergence in development between the two case countries whilst the qualitative element is seeking to explain this divergence. This is believed to be the best approach in order to grasp the perceptions of key agents about facilitating and restricting factors. It also forms part of an endeavour to introduce greater recognition of highly influential, but hitherto neglected, 'soft' aspects like culture and tradition into studies in economic geography.

For reasons of manageability of the data within the given time frame, the historical study is restricted to the time period between after World War II and 2010. Although some comments will be made on developments since then, this is not the focus of this study. The institutional comparison remains primarily on the national level. Information from the pilot study led to an emphasis on the national level as this was pointed out to be more important by respondents. Future research could address this shortfall.

1.6.2 Research Approach and Methodology

The study is based on a critical realist ontology and therefore neo-realist epistemology. This suggests that the author is interested in uncovering the mechanisms that underlie the superficially visible reality and believes that society consists of open systems where only tendencies but no definite causalities can be ascertained. This ontology has deeply influenced the creation of the conceptual framework, which also postulates a reciprocal relationship between agents and structures in an ongoing dynamic process of evaluation and (re)creation.

The study is fundamentally theory led, meaning that a theory in the form of a hypothesis and framework has been established, which was then investigated. Whilst the theory guided the fieldwork, the researcher made sure not to ignore important evidence that arose from the data and let it inform further theorisation and consequent fieldwork.

The study is an explanatory case study where a sequential, mixed methods approach has been taken to investigate the divergence between two case countries. This means that there is both a quantitative and a qualitative element. The qualitative element follows the quantitative element and seeks to explain the phenomena that are observed via the quantitative research. The main focus lies on the qualitative element.

A small number of numerical indicators were chosen to illustrate the development of the wind energy industry, the diffusion of the technology, and the socio-economic outcomes. Further commentary on the methodology and acquisition of data is provided in chapter 3, the Research Design and Methods chapter.

The qualitative research element consists of data from a total of 36 expert interviews and the study of documents. The interview data was used both as immediate data itself and as signposts towards important documents and secondary data. A pilot study with four knowledgeable experts, academics in the field of renewable energy policy, has led to a greater focus on the role of institutions in the main fieldwork of 32 interviews with experts from across the wind energy industry.

The findings from both research elements are presented in the analysis which expands over chapter 4 and chapter 5, the former being a historical analysis of the development of the wind energy industry from a path dependent perspective and the latter an analysis of the role of institutions for the development of the industry.

1.7 MAIN THEORETICAL ARGUMENTS

This study enriches the path dependency perspective with an old institutional economics view. It proposes two frameworks for the role of institutions in path dependent development and for the role of different types of institutions for institutional co-evolution with technological development and changing circumstances.

The key theoretical arguments are presented in the literature review in chapter 2: Technological development must not be understood in isolation of society and societal change. The innovation process is thus characterised by feedback mechanisms between involved agents and their environment. Industrial development is fundamentally path dependent, where the present set of choices is conditioned by past decisions. Institutions can both play a supporting or a hindering role for technological development. It is necessary, that institutional arrangements co-evolve alongside technological development and changing circumstances so that they do not hinder beneficial technological advance. Institutions are not value neutral but are humanly constructed and subject to constant re-evaluation by agents. Agents are both enabled and constrained by the present institutional constellation but they are seen to have the power to amend and therefore co-evolve it.

It is therefore argued that the industrial landscape is essentially path dependent but that the institutional constellation constitutes a filter on agents' perceptions of technological trajectories and changes of the wider environment. Furthermore both informal and formal institutions must be considered. Informal institutions can provide access channels for new ideas and approaches to problem solving. At the same time the degree of rigidity of the formal institutional arrangements determines the ability of agents to evaluate institutions and make important amendments or to even perceive the necessity to do so.

The study adopts a multi-level perspective and frames the process of transitional technological change in three dimensions or 'layers', the civil society, the institutional arrangements, and the industrial landscape. New ideas and solutions are argued to originate primarily amongst the civil society and have to gain support from the institutions. If they

gain such support they may develop and eventually new pathways may join or substitute old paths in the wider landscape. Institutional co-evolution may be necessary to allow a new pathway to develop. Between two areas or regions the difference between the institutional arrangements determines their ability to co-evolve with and adapt to changes in the environment and challenges posed by novel technology.

1.8 STRUCTURE OF THE THESIS

This thesis is structured in six chapters. This first chapter has introduced both the wider context to this study as well as the most important aspects of the study itself like the hypotheses and the methods used in the investigation. The second chapter is the literature review chapter. An overview is given of the most important theoretical concepts, which have influenced the formation of the conceptual framework and the analysis framework which guided this study. Both frameworks are explained and the hypotheses are presented at the end of the chapter. The third chapter, Research Design and Methods, begins by declaring the philosophical approach which shaped this study. It introduces the research questions derived from the hypotheses. Then it shows how these influenced the choice of methods and shaped the main fieldwork. Details are given about which particular methods were used and why. What follows is the heart of this study, the two part analysis chapter. The first part is presented in the fourth chapter. It is an analysis of the development of the wind energy industry in Germany and Britain from a path dependency perspective. The chapter is structured along four phases, a preconditions phase, a path creation phase, a path development phase, and an outcomes phase and makes continuous reference to the path dependent character of the process of industry creation. The second part of the analysis is presented in the fifth chapter. This is the analysis of the role of institutions for the development of the wind energy industry in Germany and Britain. It examines the role of both formal and informal institutions for the observed divergence in development. Finally, the sixth chapter concludes on the key theoretical arguments and on the findings from the case study and offers thoughts on the wider implications of this study for economic geography and policymaking. At the end of this thesis there is a bibliography, which cites all references that are being used and an appendix, where additional material can be found, which illustrates the steps taken to collate this thesis.

2 Literature Review

2.1 INTRODUCTION

The aim of this study is to explain the divergent development of the wind energy industry in Germany and Britain and to explore the role of institutions for this. The literature review collects and presents the key theoretical arguments, which formed the basis for the explanation for this divergent development.

Technological development and regional, industrial development are shown to be essentially path-dependent in the first part of the chapter. The study argues, however, that a path dependency perspective alone is not sufficient to explain the divergence of development paths like that of the wind energy industry in Germany and Britain. The first part therefore leads to the introduction of a multi-level conceptual framework that describes the path dependent development of technological development and its impact on the economic landscape but also points to the importance of supportive institutional arrangements for the development of new pathways. Interactions between institutional structures and other parts of the economic landscape are emphasised. The institutional arrangements filter how agents perceive technological change and changing circumstances. It is therefore important that the institutional arrangements co-evolve with such change. It is down to the agents to co-evolve the institutional arrangements or not.

This important inter-relationship between agents and institutions is the main subject of the second part of the chapter which leads on to the analysis framework. Whilst the conceptual framework just points to the role of institutions, the analysis framework shows how different kinds of institutions interact. The framework demonstrates that informal institutions crucially impact on institutional co-evolution because of their immediate influence on individuals' behaviour. Informal institutions may therefore provide access channels for new ideas to get a foothold amongst policymakers and lead to a decision to co-evolve the formal institutional arrangements. At the same time the degree of rigidity of the formal institutional environment determines whether agents are able to co-evolve institutions or even perceive a need for such co-evolution in the first place. Therefore where the formal institutional arrangements are very rigid and closed, new ideas are not able to gain the same access and institutional hysteresis continues.

The final section concludes on the key theoretical arguments and makes explicit the gap in the literature that is addressed by this study.

2.2 EVOLUTIONARY VIEW OF ECONOMIC DEVELOPMENT

This study is situated within evolutionary economic geography, which is an application of evolutionary economic thinking to questions of the distribution of economic activity in space. Evolutionary economic theory has been developed to provide alternative modes of explanation for economic development to those of neoclassical growth theory. A key focus of evolutionary studies is the historical development of a study area. Martin and Sunley (2006) emphasise that evolutionary economics does not consist of one, coherent body of theory but is a set of 'different approaches' with different foci and different foundations. There are three main strands in evolutionary theory: That of generalised Darwinism (taking inspiration from Darwin's theories about the development of species and applying it to economies and sectors), complexity theory (focused on the connectedness of processes and on spontaneous emergence of endogenous order), and path dependency theory (primarily based on the idea that present sets of choices are conditioned by past events) (Boschma & Martin, 2010). This study has an evolutionary focus in that it studies the development of an industry in two different spaces, taking a special interest in its development over time and in its path dependent characteristics and in the role of institutions in this process.

A central pillar of evolutionary theory is the premise, that the way humans behave and interact is the result of their shared experiences and habits. The maximisation premise (behaviour to maximise personal profit or utility) from neoclassical economics is rejected as an explanation of human behaviour. Improvements over time are therefore understood as the result of collective learning, which is seen as a deeply evolutionary process (Nelson, 2002). Further features are non-linearity of development, the strong inter-relationships of its components (i.e. individuals – agents), its dependence and reciprocity with an ever-changing environment, and the role of feedback mechanisms between different agents and between agents and the environment. There is also a rejection in principle of the general concept of economics of equilibria. The idea that an economy will always tend towards a single equilibrium state which is the optimal and the most efficient state is refuted by evolutionary economists and systems theorists alike (Buckley, 1998). A view of (regional) economies as open systems with emergent properties that co-evolve with each other enables an explicit account of power and agency (Nelson, 2002; Boschma & Frenken, 2007; Martin & Sunley, 2015). Nelson (1998) argues that formal growth theories focus too much on quantitative change and claims that a historic approach will bring to light a wealth of

qualitative aspects. "New technologies are emerging, and so also are new forms of business organization, and new institutions. Put another way, development is moving forwards and not simply things getting bigger or smaller or staying the same size" (Nelson, 1998, p.320).

Since the mid-1980s traditional economists have opened up to include geography and spatiality into their perspectives and economic geographers have increasingly looked towards institutional and socio-cultural modes of explanation. This has been termed an 'institutional' or 'cultural turn' in economic geography. Both provide little explanation for why economies may progress along technologically suboptimal trajectories. It is argued that evolutionary theory can fill this void by introducing an historic approach, dealing with "*path dependent* processes, in which previous events affect the probability of future events to occur" (Boschma & Frenken, 2006, p.281, emphasis in original). Evolutionary economic geography, instead of focusing on factors for agglomeration (neoclassical approach) or the specificities of institutions in different locations (institutional), conceptualises the economy as a continuous, "evolutionary process that unfolds in *space and time"* (Boschma & Frenken, 2007, p.2, emphasis in original).

Key to evolutionary economic theory is its understanding of technological development. This has its roots in the writings of Joseph A. Schumpeter and the role that he ascribes to innovation as well as in conceptualisations of technological development as a continuous, non-linear process which is endogenous to the economy (Schumpeter, 1959; Schumpeter, 1983; Kline & Rosenberg, 1986).

2.2.1 Technological Development

The dictionary refers to 'technology' as "the branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the environment", or "the sum of the ways in which social groups provide themselves with the material objects of their civilization" (Dictionary.com, 2013). Both definitions do not focus on the bare technology itself but recognise the relevance of technological development for society and culture, an indication that technological change will often have implications for the wider society. Buckley (1998) suggests that although technological innovation is understood as a source of change in economic systems there is little consideration of other forces and in particular the role of institutions that may facilitate its creation and diffusion amongst society (p.71). He sees great potential in the study of technological innovation as part of the wider system of societal changes for a genuine appreciation of the continuously evolving nature of society itself. This study aims to provide a wider consideration that goes

beyond immediate technological development to seek explanations for the divergent development of an industry between two countries. Temporal, contextual circumstances are understood as integral to the system as a whole and not just as mere exogenous factors. The role of institutions for technological development, in particular, is given explicit consideration.

Schumpeter identifies 'innovation' as the key driver for economic growth, employment, and wealth creation. He distinguishes between the 'inventor' and the 'innovator', where the latter helps the former to implement and bring to market their invention. He recognises that these are not discrete roles and may overlap (Schumpeter, 1983). Schumpeter views capitalism as an 'evolutionary process', explaining that it will by nature never be stationary and identifies innovative processes as the fuel of this 'capitalist engine'. He also recognises a second, darker aspect of economic renewal beyond pure employment growth and wealth creation. Schumpeter terms the constant process 'creative destruction' in recognition of the fact that the introduction of new products, new production processes and technological improvements to machinery will unavoidably lead to difficult processes of sectorial and social restructuring and often the loss of employment within established industries, thus manifesting a veritable threat to incumbents (Schumpeter, 1959).

2.2.1.1 Technological Development as an Evolutionary Process

Orthodox economics have treated technology as an exogenous factor to economic development and as a primarily reactive force to market mechanisms of demand and cost. A key element of the evolutionary theories of technological change is the endogenisation of technology. A traditional 'cannonball' view of technology, where technology is coming in from the outside and gets diffused and taken up for its obvious advantages, is abandoned and instead a view of technology as 'a configuration that works' is proposed. This implies a consideration of the wider system in which the technology is embedded (Rip & Kemp, 1998). Key to evolutionary economic theory is an understanding of technological change as an ongoing, evolutionary process in the Schumpeterian sense as explained above. One strand of innovation literature propagates a move away from a 'linear model of innovation' towards a 'non-linear', interactive model of innovation. The linear model describes the innovation process along a line which sets off in the realm of science and technology ('invention', research). Commercially promising inventions are developed further and prototypes are created (development). In the next phase the invention is being produced and finally the technology needs to be diffused to reach a wider audience of users.

Innovation within this model is understood as the successful introduction of a novelty on the market (Bathelt & Glückler, 2012). Rip and Kemp (1998) criticise that such linear development is rarely to be found at all, and if so, would require explanation itself. They prefer the evolutionary metaphor of the growth of yeast cells with its branches in various directions, and cross-connections and interactions (Rip & Kemp, 1998).

Bathelt and Glückler (2012) also point out critically, that learning processes are not recognised by the model even though they are crucial for reflexive behaviours which generate stepwise product and process improvements. Kline and Rosenberg (1986) also refute the linear model and instead present the 'chain-linked model of innovation'. It identifies five paths of activity. The first is referred to as the 'central-chain-of-innovation'. It runs from the identification of potential markets, to the invention and/or production of analytic designs, to more detailed designs and testing, to redesigns and production and finally to distribution and marketing. The second path is a series of feedback links between all stages of innovation and also between the market-wide distribution of a product and the potential market for new products. Science is understood as not at the beginning of the innovation process but rather as running alongside it where knowledge is brought in when needed. This constitutes the third path and the 'chain' element which gives the model its name. The 'research' element comes in when established science fails to solve a problem. Fourth, sometimes new science causes radical innovations, rare occurrences but often accompanied by major changes and the introduction of whole new industries (Kline & Rosenberg, 1986). The fifth path indicates the feedback from the products of innovation itself to science. This interactive model recognises the many potential sources of innovation (customers, users of technology, suppliers and cooperation partners can provide inspiration for innovations) and the inter-dependencies of all stages of the innovation process (Bathelt & Glückler, 2012).

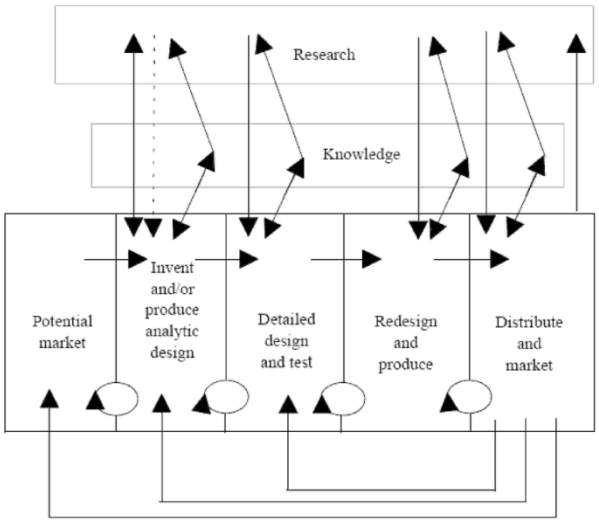


Illustration 2: Chain-link model of development (Kline & Rosenberg, 1986, illustration from OECD, 1996)

Giovanni Dosi challenges an important orthodox conceptualisation of technological change, consisting of the two key dynamics of 'demand-pull', where market forces determine technical change and demand for certain products is the driver of change, and 'technology-push', where science and technology quasi-autonomously develop and introduce new products to the market. Progress in science is seen as the driver of change. Dosi (1982) argues that the demand-pull concept reduces technological change to a mechanical, reactive role towards market conditions and, consequently, the concept is not fit to explain 'when' and 'where' certain technologies gain market dominance over others and that it completely ignores the inventive potential of science and technology regardless of market situations. He also criticises the 'technology-push' concept in that it is taking a view of science as utterly independent of all other societal dynamics and the market. It ignores the strong influence the economy has on the innovative capacity of a place or region. This argument is taken up later by the aforementioned scholars Kline and Rosenberg (1986), who emphasise the mutuality of the market and the technological development. They argue that a market need will only be satisfied if the technical challenges can be solved and that an improvement in performance will only be put into use if there is a market for it. Therefore any new market need will in time lead to a novel design and any new design will in time lead to changed market conditions. Evolutionary economic geographers share Dosi's (1982) concern for the mutual relationship between place, time and technological/industrial development.

As alternative perspectives on the innovative process Dosi (1982) presents the concept of 'technological paradigms' and 'technological trajectories'. In reflection of Thomas Kuhn's 'scientific paradigms' he defines a 'technological paradigm' which becomes a 'pattern' of problem solving for selected technological challenges. A 'technological trajectory' is therefore the sequence of normal problem solving activity following the existing pattern (i.e. progress) based on the predominant 'technological paradigm'. The reality of a 'technical paradigm' is a powerful effect of exclusion where the involved agents (scientist, engineers, etc) struggle to apply new ways of thinking to technological challenges beyond the existing solutions (Kuhn, 1962 in Dosi, 1982). Dosi (1982) explains the choice of one technological path over another by economic forces in combination with institutional and social factors, which act as selective devices by posing questions of feasibility, marketability and profitability. Similarly, when analysing through modelling the nature of the scientific endeavour itself (also in reflection of Kuhn's ground breaking work), Sterman & Wittenberg (1999) come to the conclusion that environmental factors are much more important for the dominance of one path over another than the actual quality of the paradigms themselves. "[…] positive loops can amplify microscopic perturbations in the environment – the local conditions of science, society, and self, faced by the creators of a new theory – until they reach macroscopic significance" (p.339) they say, alluding to the powerful effect of the interaction within and between paradigms which characterises path dependent systems.

2.2.1.2 National Systems of Innovation

In the early 19th century Friedrich List was struck by the difference in economic development between Germany and England. He concluded that Germany was rapidly overtaking England and put this down to a range of policies, which enabled learning of new technologies and their application including training opportunities as well as investment in the wider network infrastructure. More recently Freeman and Soete (1997) have picked up List's thoughts and propose a perspective of economic development driven by 'National Systems of Innovation'. Such systems are dense webs of different related activities "such as education, training, production engineering, design and quality control" as well as in-house R&D in major companies (Freeman & Soete, 1997, p.301). Feedback loops from the market and from production back into R&D are also considered part of this system. Freeman and Soete (1997) are critical of the heavy focus on R&D by much of the 20th century mainstream business literature but recognise its key contribution to radical innovations. They argue for a better consideration of qualitative factors affecting these

systems of innovation beyond mere quantitative input indicators. Freeman and Perez (2008) build on this, refuting the orthodox economists' view of growth, and state that stability is dependent on a wider sense of 'confidence' and "belief in the future potential benefits from technical change" and is unlikely to be based on a set of unrealistic assumptions about "perfect information and accurate calculations on the future rate of return of a wide variety of investments with uncertain outcomes" (p.41). Furthermore they, too, criticise the purely quantitative nature of most macro-economic analysis and modelling and insist that this is a restriction. They then suggest that reference to Schumpeter is useful as he specifically emphasises the qualitative aspects of economic development by framing depressions as periods of structural adjustments, where the social and institutional framework adjust to new technologies. They suggest that prolonged recessions are due to an increasing mismatch between new technologies and the existing socio-institutional framework. Wilson (2012) defines such situations as 'transitional ruptures' where community groups are able to implement change but the wider socio-institutional and political framework takes longer to adopt changes.

Lundvall (1995) insists that any definition of a system of innovation and its sub-systems and processes should be kept as open and flexible as possible to allow for different theoretical perspectives to focus on different aspects of the system. He also hints at a co-evolutionary relationship between the process of innovation, the economic structure, and the institutional set-up. He suggests that the "analysis of systems of innovation helps us to understand and explain, why technology develops in a certain direction, and at a certain rate", however he also emphasises that "a strong element of randomness will always remain" (Lundvall, 1995, p.12). Interestingly Lundvall (1995), in reference to the European integration process, argues that it will be necessary to take into consideration the interactions between institutions and economic development to promote innovation. He points to a difficulty in defining a spatial focus of both systems and the process of innovation when he argues that National Systems of Innovation ought to be seen as open and heterogenous and that "processes of innovation transcend national borders and sometimes they are local rather than national" (Lundvall, 1995, p.4).

The review so far has introduced important arguments about the non-linearity of technological innovation and about the embeddedness of the process in the wider society. Technological development cannot be seen in isolation of broader societal changes. Such a broad perspective is important and useful to study processes of transitional change, like

that of the transition towards renewable energy in the light of a global recognition of climate change. The concept of systems of innovation helps to understand the interactive nature of the innovation system, determined by agents and their interactions with each other and their environment. It also constitutes an emphasis on the qualitative aspects of the innovation process.

It is argued that systems of innovation can be deliberately formed and fostered by policymakers via industrial policy. Places where power is relatively de-centralised, however, and the institutional framework is not too rigid are better able to actively create and maintain such systems of innovation. Where the formal institutional framework displays no openness to new ideas it is unlikely that systems of innovation, even if put in place at one time, retain the necessary flexibility to continue to adapt to technological and wider societal change. An evolutionary perspective brings the recognition of historical development, which determines our present choices and aides in analysing these past processes. One strand of evolutionary economic theory, path dependency theory, is introduced in the following section.

2.2.2 Path Dependency

Path dependency theory is a strand of evolutionary theory as mentioned above. The key notion is that the present set of choices is conditioned by choices made in the past. It therefore introduces a strong focus on historical development. The above explained evolutionary conceptualisation of economic change and its non-linear and endogenous character is integral to path dependency theory. This theory is part of a set of evolutionary economic theories, which are part of the larger set of heterodox economic theories, which were developed challenging the assumptions of neo-classical, equilibrium based theory. Two of the central assumptions being challenged originally are the idea, that market forces produce the choice of the optimal technological solution and, that decisions once made are reversible and will be reversed if a better technological solution becomes available (Simmie, 2012). As the use of fossil fuels for the generation of electricity is seen as a suboptimal technology in the light of the global threat of climate change, the analysis of its persistent use from a path dependency perspective is appropriate.

2.2.2.1 Definition of Path Dependency

In order to focus the concept on its 'logical core' Vergne and Durand (2010) offer a narrow definition of "path dependence as a property of a stochastic process which obtains under two conditions (contingency and self-reinforcement) and causes lock-in in the absence of

exogenous shock" (Vergne & Durand, 2010, p.741). They suggest that such a narrow definition is important for the concept to make a real contribution in understanding phenomena beyond just seeing every historical process as path-dependent. The implication is that it is important to seek to identify these characteristics in a process to justify its analysis from a path-dependency perspective when doing so. Whilst Vergne and Durand (2010) recommend caution with regard to considering historical processes as path-dependent too readily they do specifically point out that "when we observe outcome diversity *despite* similar initial conditions, path dependence is a serious candidate to account for differential evolutionary paths" (p744, emphasis in original). This has been shown to be the case for the wind energy industry in Germany and Britain, where, despite similar starting conditions and initial path creation, the industry developed entirely differently. Therefore this provides an important argument for the use of path dependency theory as part of the primary descriptive.

Considering the usefulness of the concept for economic geography Martin and Sunley (2006) specifically point out the role of 'non-ergodicity', which they define as the inability of a system or process to shake free of its own history. Path-dependent outcomes are conceptualised as the necessary consequence of the historical development of the system or process. At its core this study focuses on different outcomes in the industrial development in two countries despite very similar initial conditions and indeed new pathways. As part of "new 'evolutionary', 'institutional' and 'relational' approaches to economic geography" path dependency is seen as a determining feature of the economic landscape. Path dependency theory aides in explaining context dependent and locally specific yet contingent patterns of economic development and the "'quasi-fixity' of geographical patterns of technological change, economic structures and institutional forms across the economic landscape" (Martin & Sunley, 2006, p.398). In other words path dependency theory might help explain, why certain regions appear to be 'set' on a particular development path, not just of economic activity, but also in terms of the supporting structures and institutions.

The wider development and change in particular of the economic system is seen as a process that is "shaped and constrained by past decisions, random events, and accidents of history. Current decisions and events are not determined by past ones, but they are conditioned by them" (Gertler, 2005, p.24). This emphasis on history adds to the economic debates and opens them up towards regarding economic change as a process beyond just functional terms, thus strengthening the argument for longitudinal observation in the

economic sciences. The concept contradicts neoclassical models of growth in that "technology is not chosen because it is efficient, but it becomes efficient because it has been chosen" (Rip & Kemp, 1998, pp.353–354). In other words, once a particular path is taken, often because of a coincidental advantage or by sheer accident, self-reinforcement or network effects may lead to it being the most efficient choice even though better paths are available. Early incarnations of the path dependency concept ascribe a key role to small incidents, often not immediately obvious as connected, and their capacity through chance to gain major significance and become the source of a whole new 'path' or industry. Further important characteristics are the reinforcement into 'lock-in' by network externalities and increasing returns, and the role of 'external shocks' in breaking out of locked-in patterns for economic systems (David, 1985; Arthur, 1989). The former describes a situation whereby the advantages of the one technological solution are so overwhelming or indeed have been so persistent that agents struggle to challenge it and change becomes nearly impossible. The best known example is the QWERTY keyboard, which is still in use on smartphone technology where it is not at all the 'optimal' (i.e. fastest or most efficient) solution for the input of letters, but any attempt to change towards another constellation would most likely fail (David, 1985). Coding languages in computing are similar examples. Once a technology has become 'standard' with other areas adopting it and economies of scale being achieved it becomes increasingly difficult to challenge its position. Early conceptions of path dependency mainly identified 'external shocks' as key stimulants to break away from locked-in patterns. The above mentioned keyboard constellation QWERTY is an example famously used in a seminal paper by Paul A David. Today's computer keyboard constellation goes back to the constellation of keys on the mechanical typewriter which was developed in the 19th century in the USA. Despite immediate problems with keys jamming, the inventor was pressed to continue with the same constellation by the investor with an aim to release the machine as quickly as possible. It was released in 1878, in competition with other writing machines that worked with different and sometimes better constellations. Yet, by coincidence, the US industry took up QWERTY and it became the standard across operations. Complementary services adapted it and eventually other producers were forced to follow as well. 'The Universal' (i.e. QWERTY) was embedded in a larger system of production beyond just manufacture, which also included those who had to work with these machines. 'Touch typing' was fully adapted to the QWERTY keyboard design right from its beginnings in the late 1880s. The key features which caused the 'lock-in' of the QWERTY keyboard are therefore technical

interrelatedness, economies of scale and quasi-irreversibility of investment (David, 1985). An important point arises from this description of keyboard development. The aspect of short-termism over longer term considerations: Short termism is often a key reason for one, suboptimal technology to be chosen over a technologically more advanced one at a particular point in time. Arthur (1989) uses economic modelling to demonstrate how, under the expectation of increasing returns, the role of 'historical events' may become magnified even if they are very small. Their influence on the inter-active process leads to one choice over the other. In the early stages a small, seemingly insignificant event may give an advantage to one pathway. This leads to an early 'cornering' of the market through one technology and the 'locking out' of potentially good alternatives. "Increasing returns can cause the economy gradually to lock itself in to an outcome not necessarily superior to alternatives, not easily altered, and not entirely predictable in advance. […] 'History' becomes important" (Arthur, 1989, p.128).

The subject matter of this study is how a once reasonable path of energy generation, the use of fossil fuels, has become increasingly suboptimal. Whilst at the time it was financially the most reasonable choice, the oil price shocks and the resulting insecurity of price, and the increasing global recognition of climate change have rendered the use of fossil fuels a suboptimal choice. A transition towards renewable fuels for energy generation is therefore needed. Fossil fuels, however, were chosen as main fuels in most countries at one time and it has now become difficult to change this path. Germany appears to have been better able than Britain to break this pattern and allow the introduction of new, innovative technological pathways. The role of contingency and self-reinforcing mechanisms in this process will be analysed in more detail in the first part of the analysis in chapter 4. The role of institutions in disrupting or reinforcing such path dependent development is the subject matter of the second part of the analysis in chapter 5.

A key feature in the concept of path dependency is the idea of a 'lock-in' situation into a particular technology or pathway. Authors describe a situation where change from within becomes increasingly impossible and suggest that 'external shocks' are the only source of breaking out of such 'lock-in'. Increasing 'inflexibility' of agents and structures is seen as a determinant property to this state (Arthur, 1989; David, 1985). Crouch (2005) suggests a more reflective agent, when he proclaims that the concept is useful to "predict and explain the otherwise irrational behaviour of an actor, who perceives that the path she is using no longer achieves her ends, wants to change it, but is unable to do so" (p.79). Martin and Sunley (2006) appear critical of the concept of lock-in, suggesting that it is not a

widespread occurrence and certainly not a state that would be expected to persist. They point towards the productive powers of such a state either in lending stability or as internal trigger for the search of alternative technologies.

The key characteristics of the canonical model of path dependency are summarised in the table below.

Initial Conditions	**Path creation processes**	**Path establishment processes**	**Path dependence outcome**	**Path dissolution**
Not specified	Historical accidents. Chance events. Serendipity.	Contingent selection. Self-reinforcing effects.	Lock-in of inefficient or sub-optimal technologies, institutions or organisational forms.	External shocks.

Table 1: Basic economic model of path dependence; Note: arrows indicate uni-directional historical development of pathway towards lock-in (Simmie, 2012)

The canonical model of path dependency reduces the emergence of novelty and therefore the introduction of new paths to a serendipitous process. This is criticised by scholars and it is suggested that new technologies do not just enter a market by chance but that this process itself is one that is characterised by path dependencies and inter-dependencies as part of a complex system of other technologies and innovative solutions (Perez, 2009). "[…] new technologies often have to emerge into a complex landscape of historical path-dependent developments which themselves may possibly provide significant barriers to that emergence" (Simmie, 2012). In other words there ought to be consideration of the existing complex, inter-active systems in place, embedded against a wider socio-political context, and having themselves historically grown. In fact it may well be those wider contextual factors that act as barriers or facilitators to the creation of new paths.

The multi-scalar conceptual framework of this study specifically recognises the interaction of new pathways with existing pathways and the wider landscape of socio-cultural factors and institutional settings. Development is shown to undergo phases which are seen as continuously repeating themselves and thereby creating the pre-conditions for the creation and development of further pathways. Change, however, is specifically seen as

originating endogenously rather than just stemming from external shocks. An explicit consideration of New Path Creation is therefore useful.

2.2.2.2 New Path Creation

Whilst the canonical concept of path dependency is focused on the development of systems and the role of historical events it says little about the role of agents within these systems and the choices they make, when they make them, and why. Change in economic systems has been found to take place in the absence of external shocks and so there was a need to explain this. Garud and Karnoe (2001) identified this weakness and emphasised the importance of human agency by introducing a focus on 'path creation'. This constitutes a shift of the behavioural premise of economics away from passive, receptive vessels towards pro-active, reflective agents. Discussing the concept of path dependency on a community level and in relation to community resilience Wilson (2012) suggests that communities are path dependent because of shared 'memory' that is passed on from generation to generation and from agent to agent. Those agents are therefore understood as 'embedded' in the same structures which they are seeking to contribute to or change. In line with such a sociological perspective Crouch (2005) identifies power relations and learning curves as the core drivers for path dependency in processes. Once agents 'learn' a technology they are increasingly unwilling and unlikely to change their ways. Crouch (2005) uses an example of cooking techniques where once an aspiring cook has mastered one technique she is unlikely to use a different one for some time. "Interests and experience alike develop around existing systems and seek to maintain and strengthen them and block potential changes, even if the existing system is failing to deliver results" (Crouch, 2005, p.81). This is related to considerable 'insider rewards' for existing powerful interests. The initial choice of pathway is therefore not necessarily understood as random but as driven by power relations. The conceptual framework to this study recognises such power relations in the form of interactions between the institutional sphere and agents from both the civil society and the wider economic landscape. The analysis framework specifies power relations more concretely. This will be described in detail further below in the second part of the literature review.

Triggered by sheer creativity or a perception that the current system is faulty, agents may actively dis-embed themselves through 'mindful deviation' from the existing regime or structure. Such 'mindful agents' carry creativity and a persistence which enables them to "to mobilise a collective despite resistance and inertia that path creation efforts will likely encounter" (Garud & Karnoe, 2001, p.2). Crouch (2005) argues that interaction between

agents is not part of initial path dependency models. Garud and Karnoe (2001) also argue that human agency is a 'relational concept'. Emerging concepts and ideas are shared and as they travel around different mindsets they are modified and adapted. The result may be very different from the initial idea. Path creators need to continuously adapt to the change of circumstances and to the emergence of other new ideas. Crouch (2005) similarly points out that entrepreneurs are developing alongside technological pathways and adapt and change.

Where pathway changes occur at the small, community level they may well act as catalyst for macro-level, transitional change (Wilson, 2012). Crouch (2005) points out that there is a risk that, where agents have strong intentions to change one path, they end up getting stuck in yet another path dependent system. They may or may not become aware of this further down the line. Martin and Sunley (2006) also refer to a concept of 'unintended consequences', where agents are granted some level of strategic action and deliberation but the actual path of development may be 'unintended' rather than a "conscious collective choice" (p.426). They further explain that they see the role of path dependency theory in economic geography to strengthen "causal, historical economic explanation involving sequential actions" for path creation over that of mere historical accidents. "[…] path dependence should highlight the interactions between purposeful action and positive unforeseen feedbacks" (Puffert, 2001, cited by Martin & Sunley, 2006, p.428).

Following a critical review of existing models of path dependency including the canonical model and the more sociological path creation perspective, Simmie (2012) offers his own 'hybrid, socio-economic model' of path dependency and path creation. This is illustrated in Table 2 below. Simmie (2012) gives consideration to institutional circumstances as well as the capacity for action by individual, 'knowledgeable' agents. Furthermore he directs our attention towards a set of barriers to new path creation and different kinds of potential outcomes.

Initial Conditions	Path creation processes	New path establishment processes	Barriers to new path creation	Path dissolution
Historical evolution of path dependent technological development trajectories.	Mindful deviation and invention by knowledgeable agents in niches.	Incremental innovation by knowledgeable agents by displacement layering or conversion. Or radical breakthrough innovation.	Historical economic selection environment. Cognitive: technological paradigms. Institutional hysteresis. Social: technological & other regimes.	New technology diffuses to achieve critical mass and tipping points. Or de-locking of existing pathways. Or continuation of path dependent development trajectories.

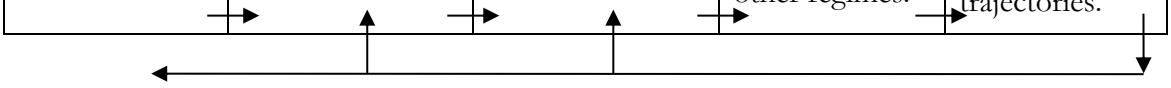


Table 2: Hybrid socio-economic theory of new path creation; note: arrows indicate direction of trajectory of new path creation and reflexive feedback loops (Simmie, 2012)

The value of this model lies within its opening up towards a view of a continuous process that contains dynamics of reinforcement, deviation, new creation and transformation, all going on at the same time within it. It recognises the possibility of path dissolution and change in the absence of external shocks and proposes different potential outcomes. Furthermore it suggests feedback mechanisms throughout the process extending the unidirectional view of development almost unavoidably heading towards technological lock-in. This hybrid, socio-economic model has substantially influenced the conceptual framework of this study. The framework builds on the insights gained from the model and increases the emphasis on the role of institutions for path creation and development.

It has been argued that technological development is fundamentally path-dependent. This means that in its present form it is conditioned by the result of past events and negotiations between agents. The usefulness of the path dependency concept and its focus on historical events has been recognised, but it is argued that the canonical path dependency model is insufficient to explain divergent development. This is because change does not only stem from 'external shocks' as the canonical model suggests. Change may

also originate 'from within'. Path creation shifts the focus from systematic dynamics and the role of historical accidents towards that of 'mindful, reflective' agents who actively engage with their environment and react to changing circumstances or consciously 'deviate' from given practices in search of better solutions. The hybrid socio-economic theory of new path creation by Simmie (2012) usefully introduces not only 'mindful agents' but also the influence of the socio-cultural and institutional environment to the model. It does this, however, as 'Barriers to new path creation' and with no explicit recognition of the important, 'facilitating' role of a stable institutional framework for path creation and development. The framework to this study seeks to recognise the potential role of institutions as both constraining and facilitating to path creation and development. 'Mindful agents' are understood to be constrained by the pre-existing institutional arrangements, but also to be enabled by them, where they are stable enough to lend security, but also sufficiently open to allow new ideas to get a foothold.

Having reviewed evolutionary perspectives of technological development, a focus on the geography of innovation processes is introduced in the following section. Having considered 'who' introduces new technologies, 'why', and 'when' the main interest now turns towards 'where' such new path creation occurs and what socio-economic as well as spatial consequences this has. This section deals with the role of 'industrial development': the localisation of industrialisation (scaling up of production processes) of both new and pre-existing technological pathways in space.

2.2.3 Industrial Development

The question of which economic activities settle and become industries in which regions and why some regions seem to be better at attracting economic activity is at the core of economic geography. Historically there has been a great variety of conceptualisations in the wider field. Chapman and Walker (1990) provide a good basic introduction to the main approaches. They describe how economic geography went from 'normative' approaches, which are mainly concerned with the optimal location for an industry at one point in time, via 'behavioural' approaches concerned with suboptimal behaviour of agents, towards a 'geography of enterprise', which recognises the impact of the environmental setting on economic activities, but which is criticised for a pre-occupation with the decision-making within large firms. Finally there is a substantial body of literature within a more comprehensive approach of regional development theory and planning. This has developed out of an inter-disciplinary concern with polarised development. Importantly, this approach

includes a specific focus on 'time' as dimension and therefore the encouragement of 'evolutionary' studies. A further step were 'structural' approaches which introduced a particular interest in the socio-economic effects of economic activity and the spatial distribution of benefits and disadvantages (Chapman & Walker, 1990).

One such 'structural' approach has been referred to as the 'Californian School of Economic Geography' (Scott & Storper, 1987). The best known approach from this body of work is the 'Window of Locational Opportunity'. This concept considers the relationship between industry and institutional structure. It suggests that in the early phase of industry development there may be a whole variety of appropriate places for production facilities, however, once an industry has settled in a location it is likely to continue to concentrate in that particular location. Whilst initial growth is seen as driven by 'external economies' through division of labour (a primarily organisational economic phenomenon), further growth occurs because of agglomeration economics (a spatial phenomenon) through beneficial linkages and inter-actions. In said locations the costs of production fall steadily and eventually the 'Window of Locational Opportunity' closes around this limited number of dominant production regions. Boschma (2007) refers to this concept and points out that the approach views industries as generators for growth themselves. Their growth instigates the development of the spaces around them rather than the other way around. Institutions then follow the emergence of these new industries and contribute to the increasing returns at that location. He also suggests that generic resources like related industries may contribute positively to the conditions for new industries in certain regions (Boschma, 2007).

One important debate within Economic Geography refers to the advantage or disadvantage of the presence of other companies either in similar or complementary industries. The former is generally referred to as 'localisation economies' (or MAR externality) whereas the latter is known as 'Jacobs' externalities'. The question is, whether new firms profit mostly from the presence of firms in the same sector or from a variety of local firms in a range of sectors. The Marshall-Arrow-Romer (MAR) theory concentrates on knowledge spill overs between firms in an industry, postulating that such local specialisation will be advantageous for growth. In contrast Jacobs (1970) suggests that the most important impulses come from outside the industry and therefore variety and diversity are better for innovation and growth (Glaeser et al., 1991). Whilst Jacobs (1970) recognises the 'efficiency' that lies in a locally specialised industry she points out the pitfalls of a lack of confrontation with new ideas and processes.

A seminal study and paper by Frenken et al. (2007) refers to three types of relationships between variety and economic growth:

1. Variety may be seen as a source of growth per se. The present industries in a region should be looked at in qualitative terms because "A region specializing in a particular composition of complementary sectors will experience higher growth rates than a region specializing in sectors that do not complement each other" (Frenken et al., 2007, p.686).

2. Regional diversification may be seen as a strategy to protect against changes in demand. High sectorial variety in a region would mean that demand shocks in one sector only have limited effect on the regional economy as a whole.

3. An economy that does not continuously increase its variety is expected to suffer from stagnation. Structural employment due to the abundance of labour following productivity increases and demand saturation in existing sectors may be curbed by the presence of a variety of other sectors.

Frenken et al. (2007) test the effects of related and unrelated variety for regional economic growth empirically and conclude that related variety, so the presence of firms in similar industries, is beneficial for regional growth whereas benefits of unrelated variety, the sheer presence of other firms, are not found to be significant. They thus recommend that regional policy should seek to enhance related variety with a view to encouraging economic growth.

Boschma and Frenken (2011) explain that proximity is an important factor for entrepreneurial behaviour as spinning out into related industries presents itself with a much lower risk to the entrepreneur than spinning out into an entirely different industry. On the aspect of cognitive proximity they point to the importance of both cognitive proximity and distance. Cognitive proximity ensures mutual understanding and learning effects whilst cognitive distance can help prevent 'cognitive lock-in', where agents within the industry increasingly struggle to think of alternative approaches to given problems. They further claim that "to foster innovation, new technologies need to be explored to examine the potential of recombinations between different technologies" (Boschma & Frenken, 2011, p.194) , a process they term 'cognitive widening' and which, in their view, is most likely to occur through the establishment of extra-regional networks.

In an extension of the related variety concept and in order to balance its strongly firm focused approach Cooke (2012b; 2012a) introduces the concept of 'transversality'.

The purpose is to recognise and reinforce the role of pro-active social agency in regional development studies. He describes an interactive process whereby "knowledge emanating from one industrial or institutional source is successfully introduced, analysed and adopted, with modifications, to facilitate the creation of an innovation in a different industry or institution" (Cooke, 2012a). The concept describes a knowledge exchange between more or less related industries within one region and Cooke suggests that this may either be invoked by the firms themselves or by intermediary organisations that identify the benefit of such a cross-sectorial knowledge exchange.

Although the concepts of related variety and transversality may offer interesting and useful insights in aspects of the process of new path creation and path development in some cases they are argued to be overly firm focused and make limited allowance for indigenous path creation driven and spurred on by the motivations and aspirations of reflective citizens. Related variety may have played a role for the development of the industry in Denmark as illustrated by Cooke (2011), and arguably transversality is inherent in '"co-evolutionary transition' to decarbonisation because many technologies and institutions must combine systemically through 'strategic niche management' to achieve it" (Cooke, 2012b, emphases by author). It is argued, however, that the development of the path and establishment of the wind sector in the present case countries cannot be explained through the presence of related industries in the relevant regions alone. Preliminary research showed that the wider environment and the supportive or respectively unsupportive institutional arrangements played a crucial role in the divergent development of the onshore wind sector in Germany and Britain.

Related variety did play a considerable role in the growth of the offshore wind sector in more recent times in Britain where companies with experience in offshore installations for the gas & oil industry were able to diversify into offshore wind energy (Ohlhorst, 2008; Dawley et al., 2015). The main interest for this study lies with the divergent development of the onshore sector until 2010 and therefore the focus was directed towards institutional arrangements and agents' perceptions of them as facilitators or barriers rather than the presence or absence of particular industries in the region.

2.2.3.1 Regional Path Dependency

Martin (2011) points out that there has been limited attention for regional path-dependency. Not many studies examine closely how whole regional economies evolve. He suggests that a view of the entire industrial and institutional system is important for such an

endeavour. Rafiqui (2009) also specifically points to the benefits of a comprehensive consideration of both technological and institutional path dependency for the evolution of the economic system. Their differences between different places and spatial scales are of great interest for evolutionary economic geography (p.347).

Multiple instances of path dependency may be expected to occur within one region and Martin (2011) emphasises that they need to be seen as inter-dependent and potentially "mutually reinforcing, and co-evolving" (p.201). Strambach (2010) conceptualises the occurrences of multiple paths within one overall 'direction' or dominant path of development as 'path plasticity'. This concept is helpful to understand the dynamics of new technologies and old technologies within the broader path towards an energy transition. She argues that 'path plasticity' is not only dependent on 'interpretative flexibility' at the micro level but also "on the elastic stretch of institutional configurations at the macro level" (p.413). In other words institutions need to be open enough to allow for different pathways to be explored at the same time within a broader direction of development. Such a view of 'plasticity' is extremely useful for the study of the path dependency of energy systems and emergent technological solutions to the 'clean' generation of electricity as future energy systems must be seen as 'bundles' of different approaches within the broader path of 'clean' energy development. Strambach's (2010) work directly points towards the need for flexibility and openness of institutions to allow for the exploration and development of new solutions through several approaches at one time.

Martin (2011) points out that for firms in a region there is a multitude of external forces that constantly confronts them with the need to innovate and adapt in order to be able to stay competitive and guarantee their survival. Entrepreneurship and learning processes therefore must be integrative to any path dependent perspective on regional development. In one study that applies the principles of path dependency to regional development, Frenken et al. (2007) suggest that there is evidence that the entry and exit of industries to a region is strongly conditioned by that region's industrial past. They claim that firms are more resilient to major shocks to the whole industry if they are interconnected well. The number of firms in an industry is expected to fall over time whilst their interconnectedness is expected to rise. As the networks and interdependencies between firms constantly increase their cognitive proximity increases, which can eventually lead to lock-in of the whole industry of a region. This is seen as typical of old industrial regions. Similarly Grabher (1993) provides evidence from the German Ruhr area that regions which were found to be strongly inter-connected (mutual dependency, entrenched

perspectives; often old industrial areas) have experienced difficulty to adapt to changes, especially in their institutions. In contrast regions that were found to be more flexible (less inter-dependencies, more progressive; typically less dependent on old, heavy industry) succeeded easier to adapt to changes and new circumstances.

Regarding the dynamics between different (old and new) pathways within the (regional) economy, Nelson and Winter (1982) see two key mechanisms at play. The first is 'substitution', where old activities are substituted by the new, innovative activity: The innovative firm grows in absolute and (in a competitive system) relative terms and attracts new resources. The second mechanism is that of 'imitation': Other firms adopt similar or the same, innovative activities and hence the innovation spreads. Such imitation processes can be heavily spurred on or deterred by the institutional framework in a system (Nelson & Winter, 1982). Similarly but in reflection of Garud and Karnoe's (2001) work Simmie (2012) focuses on the role of 'knowledgeable agents' in introducing and seeking to diffuse new technologies. Diffusion is sought using strategies such as 'displacement', where new technologies slowly become more salient than the previously dominant ones, '"layering', where new technologies are added to those already present, and conversion, where old technologies are changed" (Simmie, 2012, p.770). This focus on the agents involved in the development of new industries is an attempt to better understand how agents pro-actively seek to escape 'lock-in' situations.

Martin and Sunley (2015) suggest that the principle of 'self-organisation' from complexity studies may be translated into economic geography through a political economy view. The dynamics of capitalism produce divergent outcomes in space, producing an uneven landscape of opportunity and different responses by agents to this, which in turn shapes the landscape suggesting an interrelationship between structures and agents and a strong role of vested interests. "Self-organisation in the economic landscape is quintessentially a power-inflected evolutionary process" (Martin & Sunley, 2015, p.722). Technology is part of this process and necessarily linked with societal organisation. It cannot be seen in isolation from the society which it has been created in.

Whilst many path dependency and regional development scholars refer to aspects of technological and industrial development as drivers for regional path dependency and may mention a role for institutions the role of power relations in the initial choice of a path and the further development of one path over another has had relatively less recognition. "[…] the unequal distribution of economic resources through space is *also* a result of power dynamics" (Hassink et al., 2014, p.1299, emphasis in original). Crouch (2005) does offer a

distinctly sociological perspective of path dependency by considering this. "The path dependency differentially benefits the power holding or insider interests, but all members of the group also benefit from the fact that a solution to the collective problem has been found" (Crouch, 2005, p.156). It is important to consider such power relations as they fundamentally influence the political sphere and thus those who make crucial decisions on policy that may or may not support industries in the early stages.

It has been shown that the concept of path dependency can be usefully applied to regional economics. To do so it is important to consider the embeddedness of technological development into the socio-cultural and institutional context. The important role of institutions in particular has transpired from the review so far. To allow for the exploration of a greater variety of pathways which is more likely to generate economic development, institutions need to be flexible and open. Power dynamics are shown to be highly relevant for the path dependent development of regional economies, although they have not received much recognition in economic geography so far. The conceptual framework recognises interactions between different kinds of agents and the institutional arrangements. The analysis framework provides more detail on power relations by making the different influence on the formal institutional arrangements by 'internal' agents (policymakers) and 'external' agents (incumbent firms and civil society agents) explicit. This is explored in the second part of this chapter.

The following section introduces the multi-level perspective of evolutionary transition which has provided the core structure of the conceptual framework.

2.2.4 Multi-Level Perspective of Evolutionary Transition

At the heart of this study lies the interaction between the path dependent economic landscape, specifically the industrial development of the electricity generation sector, and the institutional arrangements which are seen as needing to co-evolve to enable technological and industrial development. Martin and Sunley (2006) suggest that the co-evolution of systems or 'arenas' like the regulatory regime and national macro-economic policy with path-dependent regional economic development is relatively unexplored. Essletzbichler (2012) points to the benefit of the use of a multi-level perspective by claiming that "The detailed historical analysis of niche, regime and landscape change to explain transitions by the MLP offers a rich picture of how new socio-technical regimes […] emerge and eventually become dominant" (p. 67).

This study seeks to make a contribution by examining the relationship between the path dependent development of one sector and the equally path dependent development of the institutional arrangements and by giving close attention to the inter-relationships and dependencies between different types of institutions and path development.

Martin and Sunley (2006) further emphasise the importance of conceptualising processes of regional 'lock in' as multi-scalar and place and circumstance dependent. Geels (2002) proposes a concept of technological transitions as major transformations in the way that societal functions (transport, housing, food, etc.) are fulfilled. He promotes a view of the transition beyond the purely technical aspect to a broad change of "user practices, regulation, industrial networks, infrastructure, and symbolic meaning" (Geels, 2002, p.1257). The change of the energy generation system from fossil fuels towards renewable energy sources may be seen as such a transition. Indeed, the German word 'Energiewende' means 'energy transition'. Kemp (1994) explains that products often start their life in a product niche, where different conditions prevail than in the general market. There is a beneficial relationship with the early customers who financially aide the development. In addition they can provide vital data for product improvement at an early stage. Radical innovations may also profit from existing, well-established sectors. They benefit from the presence of networks and relationships. Furthermore radical innovations would often combine existing technologies with the newly introduced ones or even recombine existing technologies to enable them to survive the market conditions in the vulnerable start-up phase.

Geels (2002) argues for a multi-level model of technological transition, where 'niches' are part of a 'patchwork of regimes' which forms part of the 'landscape' by which he means the deeply embedded structural trends which only change slowly. This 'landscape' is an external structure to the actions and interactions of innovators. It reinforces the idea of 'embeddedness' or in his words the 'nested hierarchy', the fact that the success of new technologies does not only depend on processes within the niche, but also within the wider regime and the sociotechnical landscape. The success of a new technology is determined by whether it is reinforced by processes at the level of the existing regime as well as the general landscape. Technologies get created and developed in technological niches. They then need to progress through a layer made up of socio-technical regimes. This can be wider restrictions like the predominant culture and symbolic meanings, existing infrastructure or more specific restrictions from existing sectorial policy, user practices, and the techno-scientific knowledge base. These will shape and influence the

development of the technology and will determine whether or not it will be further promoted. If a successful arrangement between these existing structures and the new technology is found, then the technology can become part of the landscape. The landscape itself has restrictive effects on the technology development. Innovations can also fail, if no arrangement can be found between the existing structures and the new technology or if the new technology is not fit for the landscape (Geels, 2002). This is an explicitly evolutionary perspective on the development of technology and technological transitions. Some Darwinist principles, those of 'variation and selection' are reflected in the idea of niches as places where variety occurs and regimes as the selection mechanism. The 'unfolding' aspect of evolution is represented in the idea of technological transitions as 'reconfiguration processes' (Geels, 2002).

Geels' (2002) concept of a multi-scalar model of economic development was a key influence on the author's own conceptual framework. It depicts the continuous development and change of the economic landscape as a whole. The focus is put on three key layers: the 'civil society', 'institutions' and the 'industrial landscape'. Transitional innovations are seen as originating from amongst civil society and as in need of some extent of institutional support in order to develop. If they get this support they can develop to become part of the industrial landscape. Institutions filter how agents perceive technological development and their environment and whether they will seek to put support in place (therefore co-evolving the institutions). Further details about the different 'layers' and about the framework will be provided below. What follows are the main theoretical arguments for the use of each layer.

2.2.4.1 Civil Society

Whilst academics in evolutionary economic geography recently tend to advocate a focus on the firm as object of study (e.g. Boschma & Frenken, 2007), this study puts the relationship of the citizen, society, and the environment at the centre. It thus allows for processes of invention and innovation independent of pre-existing firms. It assists a focus on the motivation and drivers for individual agents to become economic agents as inventors, innovators or entrepreneurs or for individual citizens to become activists as part of social movements that demand institutional change. Of course it cannot and does not disregard the role of pre-existing firms as resources, but it views them as part of the wider system that agents are embedded in rather than as sole key to their actions. Civil society as such plays a role in finding innovative solutions, building community, and introducing social innovation, and needs consideration for an approach within economic geography that pays

"attention to human agency and embrace[s] a people-oriented as well as a system-oriented perspective" (Bristow & Healy, 2014, p.928).

Social movements can play a key role as agents of change (Doblinger & Soppe, 2013; Vasi, 2011). Doblinger and Soppe (2013) conceptualise environmental groups as peripheral organisations (to the governmental institutions) that can utilise their peripheral position to build relations with a broad range of stakeholders, if they possess the relevant resources. Their findings suggest that well equipped environmental groups can play an influential role in creating a favourable social institutional environment for new technologies and in building pressure on governmental institutions.

In the conceptual framework the civil society is seen as the place of origin for new pathways of a transitional nature. This is a specific recognition of the capacity of the civil society to innovate as explained above. The civil society in this conceptualisation comprises a range of agents: inventors who seek to come up with new technological solutions, where they feel that there is a need, innovators and entrepreneurs who seek to bring such new solutions to market, citizens and consumers who apply and provide feedback for new technological solutions, and citizens that become activists and engage in a social movement putting pressure on policymakers to adapt the institutional arrangements, where they feel this is necessary.

2.2.4.2 Incumbent Industrial Landscape

Promoters of new pathways hope for their technologies to develop and eventually 'join' the industrial landscape either by joining alongside existing pathways ('layering' as above explained) or by substituting obsolete or suboptimal pathways ('substitution'). The wider economic landscape comprises the totality of different pathways in different sectors, the geographical distribution of different companies, their sizes and durability, "ensembles of economic agents, workers, business units, organisations, industries, and [informal and formal] institutions, and, importantly, the interactions and relations (direct and indirect) between them, and of course with other business units, industries and institutions in other regions" (Martin & Sunley, 2006, p.410, addition by author). For reasons of scope and manageability the civil society and institutional sphere are conceptualised separately, although of course they are not at all disconnected or 'separate'. Indeed, they are 'embedded' in the economic landscape. This is reflected methodologically where agents are not restricted to one role on one layer but may have several roles across all layers (see Chapter 3 "Research Design & Methods").

The conceptual framework focuses on the geographical embodiment of the economic landscape, the 'industrial landscape', which is conceptualised as being dominated by incumbent firms. Since incumbent firms have established their business in and adapted their business to the present conditions they inherently favour the status quo and can be reasonably expected to work towards its maintenance. This is recognised in the interactions between the 'industrial landscape' and institutional layer in the conceptual framework and will be conceptualised in further detail in the analysis framework.

2.2.4.3 Institutions

Institutions are argued to have a central role in economic development as they impact on whether path dependent development, characterised by serendipity, may prevail or not. This is the case because they impact on agents' behaviour directly through their crucial 'filtering' effect on agents' perception of existing technological trajectories, new technological development, and changing circumstances. In essence this study argues that institutions may provide one way for regional or national economic systems to escape lock-in situations, in other words that exogenous change is not the "only escape route" (Martin & Sunley, 2006, p.415). Despite the fact that economic geographers tend to emphasise the regional and local dimension of regional path dependency (Martin, 2008) this study is focusing on the role of institutions primarily on the national level. There is scope for the application of the framework on the regional and local levels but the focus for this study has been determined following the pilot, where participants were very clear that the key decisions for the development of the wind energy industry were made on the national level.

In relation to the role of institutions in innovation and economic development Nelson and Winter (1977) suggest that the innovation process inherently involves 'uncertainty', which may be abated by institutions. It cannot be known in advance, which technological invention will be successful in its diffusion and sufficient creation of a market to gain dominance. They infer that it is desirable that a variety of innovations are generated. A further role of institutions may be the 'selection' of innovations – in screening effectively, "accepting and spreading the good, winnowing out the bad" (Nelson & Winter, 1977, p.47).

Strambach (2010) offers a strong argument for the inclusion of institutions in economic geography, giving them a central role. She suggests that future research should focus on "institutions and institutional configurations in a more systematic way and […] analyse their impacts on the dynamic interplay between actors and structures of the

economic system in time and space" and that the discovery of these processes and their inter-action with the innovation processes on all spatial levels constitutes a valuable contribution to knowledge in the field of evolutionary economic geography (Strambach, 2010, p.425). The conceptual framework explicitly recognises institutions and their interactions with agents. A more systematic conceptualisation of the interaction between different types of institutions and with path development is given by the analysis framework further below.

The review so far has shown that it is important to view technological development as non-linear and as embedded in wider, societal dynamics. An evolutionary development perspective has been introduced and its usefulness has been argued. The importance of the creation of national systems of innovation to assist and promote path creation and development has been shown and the role of institutions in this has been made clear. Policymakers are seen as having a capacity to create and maintain such national systems of innovation via industrial policy, which ensures to foster a fertile environment for innovation through a comprehensive approach. The concept of technological path dependency has been introduced but the focus was directed towards the individuals that create new paths and the barriers that they have to overcome. The role of different drivers in industrial development was discussed and the explanatory power of the application of the path dependency concept in regional development has been argued. Finally the usefulness of a multi-level perspective of evolutionary transition processes was shown and the key theoretical arguments for the use of three layers, the civil society, incumbent industry, and institutions were presented.

Concluding the presented arguments so far technological and the resulting industrial development must be understood as a path dependent process, but existing conceptualisations of path dependency do not constitute sufficient explanations for the divergence in transitional development between two countries. The conceptual framework below presents a perspective that unites a path dependent view of techno-industrial development and recognition of the crucial role of institutions. It indicates the interactions between institutions and both the civil society and the industrial landscape as well as their filtering role of new pathways and changing circumstances for the agents.

The following section introduces the conceptual framework which has provided the theoretical underpinning for this study. This is the basis for the formulation of research questions which structured the fieldwork for this study.

2.3 THE CONCEPTUAL FRAMEWORK

Based on the theoretical grounding introduced above, the author has created a conceptual framework to guide her further research. Conceptual frameworks are useful as they illustrate how the discussed theoretical concepts are connected. They are used to structure the further research. Research questions (introduced in the Research Design & Methods chapter in chapter 3) have been derived from the conceptual framework and focused the main fieldwork.

It has been shown extensively above, that the wider economic landscape, and as part of this the industrial landscape, should be seen as a path dependent system that evolves through time, a process that is determined by contingency and self-reinforcing factors. Institutions form a filter for the perceptions of agents of technological trajectories and the wider environment. They therefore determine crucially how agents perceive and act upon new technological development or changing circumstances. Depending on this 'filter' agents may or may not perceive a need to 'co-evolve' the institutional arrangements to support emergent pathways.

2.3.1 Development Path Dependent but Institutions Matter

The conceptual framework describes the development of the economic landscape, defined above as the totality of ensembles of industries, institutions and the civil society, as fundamentally path-dependent. As this is a study in economic geography with a specific research interest in socio-technical transition the focus is on its geographical embodiment, the industrial landscape. As a particular case the emergence of the wind energy sector as part of the wider electricity generation sector has been chosen. Wilson (2012) argues that at community level "path dependency is particularly pronounced with regard to energy networks" (p.119) and it is argued that this is also the case at national level, possibly even more so. The energy sector as such is path-dependent, as it largely depends on irreversible infrastructure investments made in the past and is characterised by the complementarities and inter-dependencies between its components.

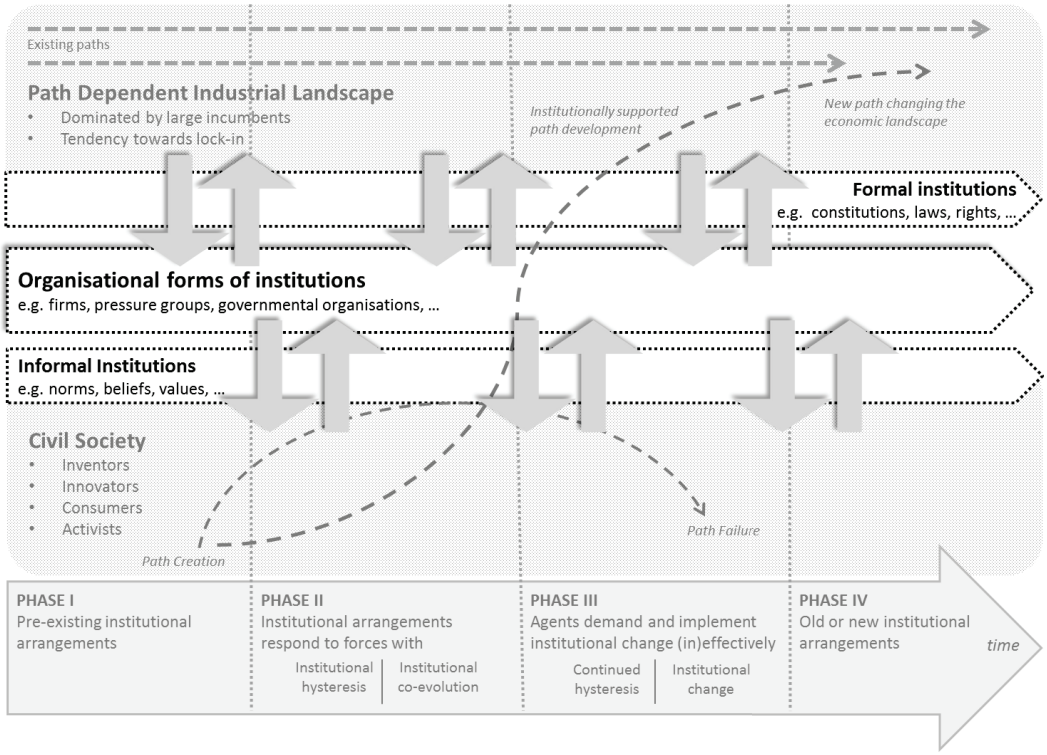


Illustration 3: Conceptual framework

The conceptual framework is influenced by critical realist ontology and therefore unites the consideration of both structure and agency and the description of industrial development as continuous and determined by the interactions between three key dimensions: the civil society, institutions and the existing industries. The civil society is placed at the bottom of the framework, the agents' roles being those of citizens, consumers and activists but also including inventors, innovators or entrepreneurs. Closely tied to the civil society are the informal institutions (values, norms, practices) that influence individuals' behaviours. At the top of the framework sits the path dependent industrial landscape. This comprises the existing industries and the pathways within them as well as their spatial character, whether they are clustered, their different sizes and how they fare over time. The industrial landscape is historically grown. It will thus be dominated by pre-existing incumbents and have a tendency towards technological lock-in. Closely tied to the industrial landscape are formal institutions in the forms of written rules, regulation, legislation. In a role as negotiators between the civil society 'core' and the landscape layer are organisational forms of institutions that can either be assistive or inhibitive to emergent technology. They are also strongly inter-dependent both among themselves and with the other types of institutions. Institutional arrangements (concurrent informal, formal and

organisational forms of institutions) are seen as pervasive as they concern and influence all agents' choices and behaviours. Agents are not restricted to be part of one 'layer' but they are likely to have several roles in society, so they can be active within more than one layer.

It is argued that agents put forward new technologies or ideas and seek for these to be supported by the institutions. Agents are seen as either driven by financial interests or ideologically motivated. The institutions interact with such new ideas by either being supportive or not, formal institutional arrangements may have to be changed, to co-evolve, in order not to hinder the new technologies or practices. The main focus of this study lies on the institutional 'layer', its internal dynamics, and its role in shaping the development of the path dependent landscape. Institutions are seen as having a fundamental influence on agents' perception of technological development and changing circumstance and over whether they will act upon this. More detailed regard will be given to institutional dynamics through the analytical framework further below.

From and between all levels, but in particular from 'the bottom up' (originating amongst civil society) as well as from 'the top down' (originating amongst the existing industries) there are forces affecting the institutional arrangements. These forces can be effective both as barriers to technological development or they can lead to the creation of new pathways. The explicit consideration of forces that are effective between levels opens the framework up to the complexity of the process of technological development and institutional change.

The framework depicts path development in four phases. The first phase consists of the pre-existing institutional arrangements that can be supportive of path creation or not. Martin and Sunley (2006) define the role of such pre-existing structures both as determined by actions taken previously and as conditioning for the present agents "by laying down an initial distribution of resources and vested interests" (p.403). The second phase describes the response by the institutional arrangements to the forces from the different levels. This can be met with institutional hysteresis or with institutional co-evolution. New paths that are met with institutional hysteresis are likely to fail or their development will experience delays. Paths that are met with institutional co-evolution will gain institutional support and will be further developed. This is described in the third phase. Agents from all levels may demand institutional change or amendments. This can be effective or ineffective which is largely dependent on the pre-existing institutional arrangements and the institutional response in phase II. If institutional change occurs, this creates a fertile environment for path development. If hysteresis continues then paths are

not likely to develop. The fourth phase shows the results of the interaction, which will be either the same or new institutional arrangements. These will create the pre-conditions for further development. This process of interaction between different levels is seen as continuous over time. The processes in each phase are a consequence of the outcomes of the previous phase.

The framework has been designed and tested in the context of two highly developed Western European democracies and therefore particular varieties of capitalism. In its current form it is not expected to be appropriate for the analysis of state directed transitions, for example in a command economy like that of China.

The conceptual framework is a visual expression of the inter-relationship between the path dependent development of the industrial landscape and institutions as well as the filtering role of institutions on agents' perceptions of technological trajectories and changing circumstances. The following section discusses the question how institutions matter in more detail and considers the role of formal and informal institutional arrangements. This leads up to an analysis framework that guided the analysis of the gathered data from the main fieldwork.

2.4 THE ROLE OF INSTITUTIONS

It is argued that both formal and informal institutions are important in the economic development of different places as they crucially impact on people's behaviour and their perception of technological change and changing circumstances. This determines whether they demand or implement institutional change which may lead to the support of one technological pathway over another.

This view goes back to the work of Karl Polanyi who could be seen as one of the forefathers of institutional theory. He spells out the necessity of a comprehensive view of society, going beyond mere market analysis, in order to understand economic processes. "The inclusion of the noneconomic is vital. For religion or government may be as important for the structure and functioning of the economy as monetary institutions or the availability of tools and machines themselves that lighten the toil of labour" (Polanyi et al., 1957, p.250). Similarly, Martin (2008) refers to economic activity as "*socially and institutionally situated*" and encourages us to understand it as "enmeshed in wider *structures of social, economic, and political rules, procedures and conventions*" (p.79, emphases in original). He re-emphasises that technological change is not an exogenous disconnected process, but

inherently socio-cultural, deeply dependant on the institutional setting, within which it takes place (Martin, 2008).

2.4.1 Defining Institutions

Among the most commonly used definitions of institutions are those by Douglass C. North. He defines them as "humanly devised constraints that structure political, economic and social interaction". He distinguishes between "informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)" (North, 1991, p.97). He emphasises their importance in reducing uncertainty in processes of exchange and production. North (1996) refers to a third type of institutions, that of organisational forms of institutions, "groups bound by some common purpose to achieve objectives" (p.5). These may be political and governmental bodies, economic bodies, social movements or educational bodies.

Giddens (1984), too, refers to different kinds of 'rules' and weighs up their effect on daily social exchanges. He points out that often those rules that do not superficially appear to have great impact on social activity, those "seemingly trivial procedures followed in daily life" (Giddens, 1984, p.22) are actually having a greater impact than formalised rules. North (1996) recognises the important role of "the perceptions of actors […] because ideological beliefs influence the subjective construction of the models that determine choices" (p.104). It is argued in this study that informal institutions are important for regional development, because they impact on individuals' behaviour and therefore on their choices with regards to the institutional arrangements and the support for emergent technologies. Emotive drivers for innovation, although influential, have been hitherto under-estimated in innovation studies and regional economic development studies as they are difficult to capture and immeasurable. Scholars have used the concept of 'social capital' in econometric studies using results from surveys on the inter-connectedness between agents and their perceived embeddedness in their communities. However, there are few studies that go beyond this measurable 'informal institution' to explore the actual norms and beliefs that individuals carry with them and that undoubtedly have a fundamental influence on their behaviour.

Whilst North (1991; 1996) provides a definition of 'institutions as constraints', Nelson (2002) propagates a conceptualisation of institutions as 'social technologies' instead. He encourages a positive view of institutions as definitions of the most effective ways of getting "things done where human cooperation is needed". To illustrate his point he

compares established institutions with a "paved road across a swamp. To say that the location of the prevailing road is a constraint on getting across is basically to miss the point. Without a road, getting across would be impossible, or at least much harder" (Nelson, 2002, p.22). This is a reference to the important positive effect that the prevalence of institutions over time may have in providing certainty and stability. This study applies such an enabling view of institutions, but argues that there is a need for institutions to develop alongside technology and adapt to changing circumstances in order not to lose this enabling property.

Scholars of economic geography, although beginning to appreciate the role of institutions and bringing them into analyses of economic development and its spatial dimension, have tended to apply a definition of 'institutions as organisational routines' which is strongly focused on firm dynamics and decision making. Boschma and Frenken (2009) apply such a view and come to the conclusion that "institutions may not play a decisive role or only an indirect role by stimulating localised knowledge spill overs and spinoff dynamics" (p.155), thereby keeping the discussion firmly focused on firm dynamics. The author disagrees with such a view and postulates that both informal and formal institutions can crucially impact on industrial development through their direct influence of people's behaviour. Both kinds therefore deserve explicit consideration. Other scholars like Hassink et al. (2014), also emphasising the need for the consideration of institutions in economic analysis, argue for a broader approach to institutions that goes beyond micro-economic considerations and reaches out across multiple levels instead of modelling "an almost linear relationship between organisational routines and institutions" (Hassink et al., 2014, p.1298). They point out that a mere focus on firm dynamics ignores the enabling capacity of those institutions that made the creation of internal routines possible. Institutional economic geographers therefore ought to keep the taxonomy of institutions sufficiently open so as to consider their impact on all citizens of a place or region.

Institutions are often referred to in daily exchanges and hence many different conceptualisations from different perspectives exist. North's taxonomy of institutions as introduced above distinguishes between informal and formal institutions and organisational forms of institutions. Organisational forms of institutions and formal institutions are considered as part of the 'formal institutional arrangements' in this study as the former are crucially determined by the latter. North's taxonomy is useful as it is sufficiently clear and yet flexible for use in further theoretical conceptualisations. This taxonomy can be applied

to the whole of society beyond just the dynamics in firms or other organisations. Since it is argued that transformational innovation can originate amongst the civil society this aspect has been central for the creation of an explanatory vehicle.

2.4.2 Agents and Institutions

Men make their own history but not in circumstances of their own choosing

(Marx, 1954, cited by Jackson, 2010, p.65)

The framework conceptualises agents as being in a continuous reciprocal relationship with institutions. Institutions get produced and reproduced through the conscious or unconscious actions of agents. Whilst they are 'constrained' and 'enabled' by the pre-existing ensemble of institutions they also possess some capacity to amend institutions to support innovative pathways if they perceive a need to do so. It is argued that the degree of rigidity of institutions crucially impacts on whether agents are able to make such amendments or even to perceive a need for change.

The institutional constellation impacts on their interests and even on their identities. At the same time those same institutions have been (re)created "in relation to stable configurations of actors with particular (institutionally defined) identities and interests" (Jackson, 2010, p.65). Thelen (2009) also emphasises the fact that institutions are not just 'received' by agents but are "always interpreted, enforced, and enacted" (p.490) by agents. Those agents that 'create' institutions therefore usually lose most control over the use that their 'design' is put to. She criticises path dependency in this point claiming that its view of the relationship between actors and institutions is one-directional. It views agents as adapting to the prevailing institutions and fails to recognise their pro-active role in building and amending institutions. "By focusing on the political coalitions and ongoing political manoeuvring among what we might think of as institutional 'rule takers' […] and 'rule makers' […] we open up room for talking about strategy, conflict, and agency as important *all the time*, and not just in those rare moments when structures break down entirely" (Thelen, 2009, p.493, emphasis in original).

Jackson (2010) alludes to scope for the individual agent for (deviating) action from existing structures but also postulates that this is an under-explored concept. The author draws on a well-known conceptualisation by the philosopher and social scientist Anthony Giddens. In response to bodies of philosophical theory which tend to focus on either 'structure' or 'agency' Giddens (1979) proposes the concept of 'structuration', whereby 'structure' bears the characteristic of 'duality'. This means "that the structural properties of

social systems are both the medium and the outcome of the practices that constitute those systems" (Giddens, 1979, p.69). A pure equation of 'structure' with 'constraint' is refuted and structure is seen as both constraining and enabling in reflection of the stability it may give to social exchanges over time and space. Giddens (1984) defines 'structure' as those properties that allow the connection of time and space in social systems, which enable similar social systems to exist throughout longer periods of time, and which contribute to their 'systemic' form. He goes on to say that the practices which prevail over the longest time period and the widest space can be referred to as 'institutions'. Furthermore he explains that institutions do not exist 'behind the backs' of social actors, but that they are an important part of society and its creation and recreation. He also advocates an 'active view of agency', suggesting that agency is not merely a reference to people's intentions but to their capacity to realise these intentions (Giddens, 1984; Giddens, 1979).

Thelen (2010) advises that it is important to inject agency into institutional studies in a way that rises above an immediate case and "generate[s] portable propositions that allow us to identify broader patterns of politics and political dynamics" (Thelen, 2010, p.55). Both the conceptual framework (see above) and the analysis framework (see below) of this study have been developed to explicitly recognise this reciprocal relationship between agents and structures and seek not to over-emphasise either. The frameworks embody an understanding of citizens in their various roles across society (as inventors, entrepreneurs, activists, policymakers, business people, etc), as the agents that interact with, are influenced by, create and recreate institutions through their behaviour, in a continuous process over time. Institutions are seen as the product of historical interactions and power relationships. Both frameworks are transferable and can be applied to different countries, regions and industries. They are meant to provide vehicles to 'identify broader patterns of politics and political dynamics' as per Thelen's (2010) recommendation.

2.4.2.1 Institutional Entrepreneurship

Kemp (1994) puts a significant emphasis on the role of policy makers in innovation processes and in particular in transformational innovation. He recognises the difficulty of their role in having to choose one technology over the other early on, but points out their responsibility not to prevent potentially important development. He specifically refers to the creation of market 'niches' through public policy for technologies with potentially high environmental benefits, which would give innovators the space they need to develop and test their technologies (Kemp, 1994). Kemp et al. (1998) pick up the concept of niche creation and propose a definition of 'strategic niche management' meaning the deliberate

"creation, development and controlled phase-out of protected spaces for the development and use of promising technologies" (Kemp et al., 1998, p.186). The purpose of such 'strategic niche management' is to understand the desirability of certain technological directions and to inform strategic decision making as a consequence. Furthermore such 'strategic niches' will assist the further development and application of technologies that have been considered 'desirable'. The approach recognises the interactivity of learning processes by intentionally creating space for the creation of networks and feedback as part of the development process. As niche creation is an evolutionary process it cannot be controlled, however, government can contribute in a considerate way to the process by the strategic choice of technologies and enabling environments for experimentation. Kemp et al. (1998) refer to such an enabling rather than regulating role for policymakers as 'socio-technical alignment policy'.

A concept that has received considerable attention more recently is that of the 'institutional entrepreneur'. This refers to "actors who have an interest in particular institutional arrangements and who leverage resources to create new institutions or to transform existing ones" (Garud et al., 2007, p.957). The concept specifically emphasises the role of agency, interests, and power relations for institutional research. Rather than accepting a view that agents are primarily influenced by institutions and tend to accept and perpetuate their structures, this approach allows for agents that apply entrepreneurial creativity towards institutions themselves and thus concentrates on processes of institutional change. The perspective sees agents as reflective and knowledgeable and possessive of an ability to challenge and go beyond existing rules and behavioural routines. They are also highly skilled and "can draw on existing cultural and linguistic materials to narrate and theorise change in ways that give other social groups reasons to cooperate" (Garud et al., 2007, p.962). The analysis framework reflects this view of institutional agents having the potential of becoming institutional entrepreneurs through its explicit emphasis of their 'power to change' the institutional arrangements. This 'power', however, makes them the subject of influence-seeking by both activists on behalf of the civil society and representatives of the incumbent industry.

According to proponents of the concept 'institutional entrepreneurs' mobilise 'collective inactivity' using a variety of different strategies. Wijen and Ansari (2007) explain one such strategy as the creation of "common ground and coincident interpretations by promoting overriding values that all accept" (p.1085). They point to the importance of building alliances amongst agents and interests. This is highly relevant for the case of

Germany, where the shared sentiment against nuclear power became an increasingly strong motivator for both civil society agents as well as policymakers to act and amend the policy framework in order to support alternative means of energy generation. Individual charismatic agents were able to build lasting coalitions across the political spectrum to mobilise resources to make the relevant changes to the institutional arrangements.

2.4.3 Institutional Economics

According to Hodgson (2000) the term institutional economics dates back to a meeting of the American Economic Association in 1918 where the importance of basing economic theory on acceptable assumptions of human behaviour was recognised and the neglect of institutions by neoclassical economic theory was criticised. Hodgson (2000) refines existing concepts and defines five key propositions for institutional economics:

1. Despite its practical focus institutionalism does not define itself through policy proposals.
2. Institutionalism is decisively inter-disciplinary.
3. Institutions are seen as key to any economy and institutionalism must therefore study the processes of institutional conservation, innovation and change.
4. The economy itself is understood as an open, evolving system with interactions with its environment and determined by social, cultural, political, and power relationships.
5. Individuals are not utility maximisers. They are institutionally and culturally situated.

The behavioural premise from proposition five is the aspect that differentiates 'old (or original) institutionalist economics' from 'new institutional economics'. Whilst the latter tends to assume utility maximising agents, the former does not and asserts an embedded and irrational, often emotional agent instead. This leads to a much more complex view of the idea of 'markets' than that of 'neoclassical economics' provides. In fact, Chang (2002) goes as far as to claim that all economic action is politically determined including market relationships. He regards 'markets' as just one of the many institutions that determine our daily interactions and exchanges and suggests that "we need an explicitly 'institutionalist' perspective that incorporates non-market, non-state institutions as integral elements, and not simply as add-ons" (Chang, 2002, p.546). He advocates an 'institutional political economy' which "treats politics not as something alien and damaging to the market but as

an integral part of its construction, operation and change, although it acknowledges the harm that excessive politicisation can do" (Chang, 2002, p.556).

2.4.3.1 Original (Old) Institutional Economics (OIE) and New Institutional Economics (NIE)

New Institutional Economics originates from a publication by Oliver E. Williamson from 1975. The point of departure for his book 'Markets and Hierarchies' are transactions between firms. He asks how institutions can best accommodate and assist transactions. He argues that actors have different strategies available and will select the most efficient one. "When that choice is made, none of the actors in the system has an incentive to adjust his or her position; this is called an equilibrium." (Groenewegen et al., 2010, p.68). When there is a change in an external variable, the agents are expected to make a further choice of governance structure, that of the cost-minimizing option in light of the changed variable. Because of his focus on firms and contracts which are institutions, Williamson has termed the approach 'New Institutional Economics' to delineate it from the existing institutional approach, which has had a broader and more interactive view of institutions (Groenewegen et al., 2010).

OIE applies a more dynamic view of institutions. It is especially interested in how they change and evolve over time and how agents adapt their behaviour in the light of changing circumstances. It allows for more interaction between agents and their environments. Agents are recognised in their complexity and special attention is given to matters of 'power and interest' (Groenewegen et al., 2010).

Hodgson (2000) advocates adopting the perspective of 'old institutionalism' as "Conceptions of social power and learning can be placed at the centre of economic analysis. This means that institutionalism is more able to address questions of structural change and economic development" (p.328). He does also recognise, however, that this makes economic analysis "much more complicated and less open to formal modelling" (ibid). This study follows an historical institutionalist approach which is focused on the evolution of institutional structures over time and its inter-relationship with the development of capitalism. Institutions are understood as products of conflicts and negotiations between different groups in society and "stress is put on the asymmetric power relations associated with institutions, and on major periods of transformation in the institutions of economic regulation and governance" (Martin, 2008, p.82). Thelen (2010) emphasises that such an historical institutionalist approach unites both a structuralist (VoC – see section 2.4.3.2 following below) and a strongly agency focused ('pragmatic

constructivist'[1]) approach in the analysis of change. However, she sees the benefit in "its view of institutions – seeing them not simply […] as coordinating mechanisms allowing actors to achieve joint gains from cooperation, but rather as deeply political and contested, as underpinned by power relations and fraught with distributional implications" (Thelen, 2010, p.54).

Setterfield (1993) criticises 'old' institutional economics in that their focus lies on "'structure' (i.e., institutions) over 'action' (i.e., the choices and activities of individuals) in the determination of economic outcomes" (Setterfield, 1993, p.757). He suggests that this might not give enough recognition to the actions of individual goal-orientated agents in shaping the institutional environment and in determining economic outcomes according to their own goals. He emphasises that this is particularly true where institutions are seen purely as constraints on social and economic progress. At the same time he addresses criticism toward 'new' institutional economics in saying that their sole focus on human choice and their view of individuals as optimising agents reduces the economic structure to a strictly 'uni-directional' one where human choices give rise to institutional structure and the possibility of a reverse causality is denied.

2.4.3.2 Varieties of Capitalism

One strand of comparative institutional theory has focused on the explanation of institutional change and development on the national level through studies of the 'Varieties of Capitalism' (Hall & Soskice, 2001).

In its basic form the concept proposes a distinction between 'coordinated market economies' (CME) and 'liberal market economies' (LME). The latter are seen as primarily leaving economic development to 'markets', driven by a belief in their 'efficiency' and in the benefits of 'competition'. Economic decisions are usually made, utilising the calculations and modelling based on neoclassical economics. CME are seen as more dependent on relationships beyond the market. "These non-market modes of coordination generally entail more extensive relational or incomplete contracting, network monitoring based on the exchange of private information inside networks, and more reliance on collaborative, as opposed to competitive, relationships to build the competencies of the firm" (Hall & Soskice, 2001, p.8). Wood (2001) suggests that the quintessential examples of such CMEs and LMEs are Germany (CME) and the United Kingdom (LME). He claims

[1] "The pragmatic constructivist is happy to accept the scientific realists models as a base which must then be modified to account for boundaries, constraints, and the manifold possibilities inherent in the interactions of large numbers of autonomous and semi-autonomous agents" (Lissack, 2013)

that in Germany governmental intervention is limited in its degree and type through institutional guarantees. This, he claims, is essential to supply side coordination in Germany. Since similar institutions are absent in Britain, he claims that non-market coordination is more difficult to sustain. Wood points to higher risk for employees in encouraging flexible tasks or teamwork and informal networks amongst highly skilled labourers in LMEs, as there are fewer supportive institutions and coordination practices. As a consequence those activities that involve standardised processes of work are much more resilient. In CMEs public policy provides a level of protection for the employees, which enables them to engage in learning activities and to organise in representative groups. In LMEs organised labour is dis-incentivised as much as possible as it is seen as too much of a strain on the production costs. Employment protection is at a minimum whilst flexibility of contracts is maximised.

Germany's federal structure and further external constraints guarantee that one single party or political movement cannot become too dominant (Schmidt, 2003). This is different in Britain where "a combination of the doctrine of parliamentary sovereignty, a first-past-the-post electoral system, and strong, internally hierarchical political parties gives Britain enormously powerful single-party governments" (Wood, 2001, p.225). He indicates that a party, once elected into Westminster, is free to do almost anything they wish with relatively few checks and balances in place beyond the non-elected body of the House of Lords, a level of power that is unique to Britain. One consequence is that radical policy initiatives are more likely to be successful in the United Kingdom whereas policy is more likely to extend beyond the electoral cycle in Germany. Wood (2001) argues that because of this potential volatility of policy in the UK companies are more hesitant to invest in networks of coordination and that uncertainty is therefore inherent in its political economy.

The approach has been widely criticised mainly for its nation-centred approach and for a lack of consideration of differences between sectors (e.g. Crouch et al., 2009; Crouch & Voelzkow, 2009; Crouch, 2005; Rafiqui, 2010). It does provide a useful contribution to this study, however, in its focus on the important role of some of the most influential national structures like the voting system and the resulting political dynamics. The particular circumstances of the chosen case of the wind energy industry in Germany and Britain have led to the focus of this study remaining on institutions on the national level.

2.4.4 Institutional Change and Stability – Co-evolution vs Hysteresis

The study argues a key role for institutions in supporting new pathways and emergent industries. In order for such support to be implemented the formal institutional arrangements are likely to need to be changed and thus to 'co-evolve' with technological development or changing circumstances. The previous sections above have discussed a view of institutions that allows them to be both enabling and constraining. Institutional change may therefore both be productive or disruptive depending on the circumstances.

North (1991) proposes that institutions evolve incrementally and conceptualises history as a story of institutional evolution. He suggests that the evolution of the institutional structure is the incentive structure for economic growth, stagnation, or decline. North (1996) describes institutional change as "typically […] marginal adjustments to the complex of rules, norms, and enforcement that constitute the institutional framework" (p.83) but also points to the importance of institutional stability in providing the safe environment in which to go about daily life and which supports economic exchange. In a refinement of this Martin (2008) suggests that institutional evolution "consists of periods of relative stability (or slow change) punctuated historically by phases of major transformation" (p.85). He continues to explain that institutions are inherently inert and durable, which are exactly the characteristics that agents are depending on for stability and continuity to go about their daily lives and interactions. North (1991) proposes that the path dependence concept cannot only be applied to processes of technological change but also to those of institutional change.

Setterfield (1993) also applies the historic path dependency argument to institutions and examines their role for the economic development. He proposes a view of the relationship between institutions and the economy as naturally 'hysteretic' whereby "institutions act as exogenous constraints in the short run, but in the long run, they are endogenous to the workings of the economy" (Setterfield, 1993, p.761). Martin (2008) views this short run exogeneity of institutions in connection with the aforementioned periods of institutional stability and the long-run endogeneity of institutions with periods of substantial institutional change. This view supports the possibility that inefficient institutions can pertain over time – they may experience 'lock-in' mechanisms. Setterfield thus suggests that institutions should be seen as "evolving, non-optimal, path-dependent phenomena" (Setterfield, 1993, p.769).

Historical institutionalist Kathleen Thelen sees a crucial role in understanding institutional change and stability in the underlying structures underpinned by power and distributional contests. "Considerations of power lie at the centre of historical-institutionalism as an approach to the study of politics, and power-distributional struggles define this approach's distinctive perspective on institutional evolution and change" (Thelen, 2010, p.43). She concludes that it is important to move beyond studies of the functions of institutions to those that focus on the "political coalitions that support and sustain them and to political contests over the form these institutions take and the uses to which they are put" (Thelen, 2010, p.57). Thelen's (2010) recommendations are reflected in the analysis framework, where the pressure that civil society agents and incumbent firms can put on policymakers in order to gain influence on the formal institutional arrangements is made explicit.

Nelson (1998), too, argues that according to historical accounts the institutional environment itself is subject to changes and adaptations in response to the dynamics of the development of a new industry. He suggests a pivotal role not only of private firms, but also of organisations like industry associations, technical societies, universities, courts, government agencies, legislatures, etc. because of their ability to adapt to technological, organisational or societal change. "New technologies often are not well accommodated by prevailing institutional structures, and require institutional reform if they are to develop effectively" (Nelson, 1998, p.330). Rip and Kemp (1998) conclude that for radical innovation to occur and for transformational development to be allowed "institutional and regulatory changes must take place" (p.364). Similarly Perez (1983) emphasises that substantial techno-economic change requires an equally substantial change in the accompanying institutional conditions, a process which is described by Freeman and Perez (2008) as 'major structural crisis of adjustment'. "It is only when this is achieved and the enabling context is in place that the full wealth-creating potential of each [technological] revolution can be deployed" (Perez, 2009, p.199, addition by author). Rip and Kemp (1998) offer a perspective of pro-active institutions which ought to be able to learn, to possess the ability to constantly evaluate the environment and where needed to adapt systems of production and innovation to changing circumstances. Further to previous explanations Nelson also propagates a view of economic development as the matter of a co-evolution between technological advance, sectorial structure, and supporting institutions, even going as far as to declare this 'co-evolutionary process' as the main force behind economic growth (Nelson, 2002).

"*Coevolution* occurs as two or more parts of a field evolve together, not perfectly, but with slippages across time and space. In doing so, the coevolving parts may both enable and constrain each other through feedback that can be negative or positive" (Garud & Karnoe, 2001, p.11, emphasis in original). It is argued in this study that there must be institutional co-evolution with technological development. The two dimensions from the economic landscape develop alongside each other, not perfectly, but much as Garud and Karnoe (2001) suggest with 'slippages across time and space'. As they do so they may enable or constrain each other throughout different periods in time. The analysis framework conceptualises this as an ongoing dynamic of (re)production between the agents and structure at its centre.

This second part of the literature review has provided an overview over key perspectives on the role of institutions. Whilst the previous part concluded that the path dependent development of the economic landscape is crucially influenced by institutions, this part deals with their influence in more concrete terms. Three types of institutions were introduced according to Douglass C. North's definition. It has been explained that using a taxonomy based on North's work is helpful because it provides sufficiently open and flexible definitions for further conceptualisation in a framework. An understanding of the relationship between agents and institutions as reciprocal has been laid out. Whilst agents are constrained by the institutional settings, they also possess a capacity to evaluate and change them, where they see a need to do so. The frameworks deliberately emphasise this reciprocal relationship. The concepts of institutional entrepreneurship and strategies for 'collective mobilisation' have been explained. Then the field of institutional economics was introduced and the particular focus on original or old institutional economics was justified. This approach is useful because of its refusal of the neoclassical behavioural premise of maximising agents, a dynamic view of institutions and a focus on the role of power relations in institutional change. Aspects of the Varieties of Capitalism, especially its interest in political dynamics and the voting system also contribute to the comparison of two nation states in this study. Finally the important role of institutional co-evolution with technological development and changing circumstances was discussed. Institutions need to co-evolve to enable and not to hinder technological development. It is argued in this study that the rigidity of the pre-existing institutional arrangements impacts on whether agents are able to co-evolve institutions or even perceive any need to seek such change. Further detail on the role of each type of institution is given in the discussion of the analysis framework in the following section.

2.5 THE ANALYTICAL FRAMEWORK

Based on the above explained theoretical grounding as well as on the conceptual framework, the author developed a more detailed analytical framework. The analysis framework maintains the multi-level character of the conceptual framework and an indication of path development but illustrates the role of each type of institution. Informal institutions are suggested to crucially impact on the ongoing process of institutional co-evolution or continuing hysteresis. This is because they directly influence individuals' behaviour and thus may motivate them to seek change. New ideas tend to form in the realm of informal institutions and they therefore provide access channels for them to get a foothold amongst those who are working within organisational forms of institutions and in particular amongst policymakers. At the same time, if the formal institutional arrangements are too rigid, this is prevented. This is because agents are then unable to make amendments to the institutional arrangements or are even prevented to perceive of any need to do so in the first place. In contrast if they are quite open and power is dispersed among the formal structures then agents will be free to perceive whether change is necessary and to make amendments where needed.

Informal institutions have hitherto been considered mainly as social capital in economic geography. This is a measure of the inter-connectedness between agents in a locality and beyond, which is established via social surveys and can therefore be expressed in numerical form. This study goes beyond this notion and opens informal institutions to a wider conceptualisation as 'norms and belief systems that influence people's behaviour in everyday life'. This is a conceptualisation that is much harder to grasp and measure, but it is argued that, because of the crucial impact of informal institutions as explained above, it is important to include such a perspective in institutional economic geography.

2.5.1 The Interaction and Inter-dependence of Institutions

The key argument is that informal institutions, through their impact on the behaviour of agents, critically influence the degree to which the formal institutional arrangements co-evolve with technological development or changing circumstances. At the same time the degree of openness of the formal arrangements conditions the ability of agents to instigate institutional co-evolution.

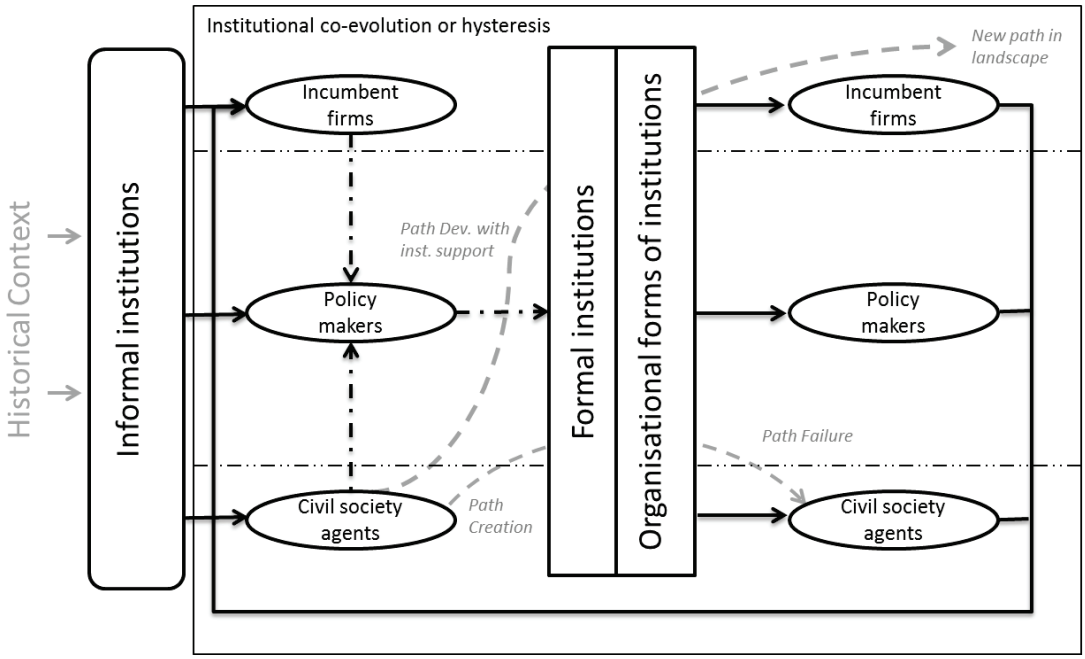


Illustration 4: Analytical Framework

At the core lies the ongoing dynamic of institutional co-evolution or continuing hysteresis. There are three key types of agents defined in the analysis framework, which maintains the multi-level character of the conceptual framework. At the core there are 'civil society agents'; these are the citizens and consumers but also include activists on behalf of social movements and small, innovative entrepreneurs. As part of the industrial landscape the framework defines 'incumbent firms' who will have a tendency to demand that existing formal arrangements are not changed because this is where their businesses have been established and what they are adapted to. Changes might be costly and against their interests. Both of those types of agents may put pressure on the 'policymakers' to change or maintain the formal institutional arrangements either directly or through organised action. 'Policymakers' are internal to governmental organisational forms of institutions and therefore have direct access and power to change the formal institutional arrangements. They will usually be politicians and civil servants although the latter do not share the power

of the former. Politicians are usually elected and therefore accountable to their constituents. It is, however, important to remember that they are also reflective agents in their own right and will bring interests as well as attitudes, values, and norms to their work.

In addition to the pressure from other agents onto the policy makers the framework makes explicit the influence of informal institutions on all agents' behaviour and thus on the process of evaluation and reinforcement or change of institutions. Agents meet the pre-existing institutional arrangements (formal institutions and organisational forms of institutions) and are both constrained and enabled by them. They do, however, have some capacity to evaluate and amend them in light of technological innovation or changing circumstances. If they act on this capacity, then institutional co-evolution occurs. If they fail to do so, institutional hysteresis may continue. The thus maintained or amended institutional arrangements carry on constraining and enabling agents and so forth. The author argues that this process is critically shaped by informal institutions as they impact on agents' willingness either to accept the existing arrangements or to make amendments. Thus informal institutions can provide access channels for new ideas, leading to formal institutional change. At the same time the pre-existing formal institutional arrangements may be so rigid that they prevent such access channels and agents are likely to accept and perpetuate a status quo. The degree of their capacity to change and amend (i.e. co-evolve) institutions depends on the malleability of the formal institutional arrangements, which is largely determined by history. The informal institutions themselves are influenced by contextual factors including the pre-existing formal institutional arrangements. Whilst the policy making process is generally a tangible and traceable process the role and influence of informal institutions is much more intangible and harder to trace. Yet it is powerful and pervasive as it influences the ways that agents perceive their scope for action.

The study argues that both formal and informal institutions have a crucial influence on where, when and how industrial development occurs and therefore economic geography should consider them explicitly through the application of a comprehensive perspective of institutions beyond strictly measurable dimensions.

2.6 CONCLUSIONS

2.6.1 Gap in Literature

The author's frameworks are somewhat eclectic combinations of different schools of thought. In their focus on innovation as the key driver of economic development and on its qualitative characteristics they are Neo-Schumpeterian. The interest in the agents involved in the innovation process, the historical focus and the interest in the effect of economic development on different places makes it a study in evolutionary economic geography. Understanding agents as socially embedded and as shaped by society but institutions also as shaped by individuals both stem from critical realism and are essential to Institutional Economics. The decisive focus on the role of agents and the view of them as enabled and constrained by the institutional arrangements derive from sociological perspectives.

Recent work on the role of social capital for regional development by Cortinovis et al. (2016) points to a gap in the existing literature where they claim that "the influence of various types of formal and informal institutions on the process of regional diversification is still rather unexplored in the literature" (p.23). Although this is not a study specifically about regional diversification, their wider argument still holds for studies about regional development in general. Whilst there is plenty of literature on both the concept of path dependency and on institutional economics and some consideration of both concepts in combination, this study proposes a model of the interaction between both a path-dependent economic landscape and institutions (conceptual framework) as well as between different types of institutions, their inter-actions and their inter-dependencies. It considers the role of this for industrial development across areas (analysis framework).

Both the conceptual framework and the analysis framework are powerful in that they are transferable. Not only can they be used as vehicles of analysis for the relationship between path-dependent economic landscapes and institutions as well as that between different kinds of institutions on a national level, but they can also be scaled down to focus on regional or local institutions. They may also be applied to study the development of different industries, which are strongly path-dependent in nature or the role of institutions in other countries of the world.

2.6.2 Key Theoretical Arguments

This study proposes a combined view of the path-dependency of the economic landscape and the role of institutions. Two models are introduced as vehicles of analysis for these dynamics, one as a conceptual framework and one as an analysis framework.

The literature review in this chapter has shown that technological development should not be seen in isolation. It must be understood as embedded in the wider societal dynamic. It is a non-linear process, dominated by feedback mechanisms with different groups of agents. Technological development and the resulting industrial development is often path-dependent in character, meaning that present sets of choices are shaped by past decisions, that development tends to occur in a contingent manner and that the process is dominated by self-reinforcing mechanisms leading to both vicious and virtuous circles. There is a distinct sociological dimension to technological development in that it cannot occur without the support from those who use a technology and also without the support and security that a stable framework will give. Institutions play a significant role in that they provide such a stable framework and can favour or hinder particular technologies. Therefore it is necessary for the institutional arrangements to co-evolve alongside processes of technological innovation to allow technological development. Institutions themselves are not neutral but humanly constructed and subject to evaluation and redesign by agents and therefore fundamentally path-dependent. Agents are both constrained and enabled by the present institutional constellation. They are seen as having some room to overcome their constraints and amend formal institutional arrangements. Those closest associated with formal institutions (policymakers) have the most power to do so. Both citizens and incumbent firms can thus be expected to seek to influence them. History is the key influence for which institutional arrangements are present today and how they affect agents.

The study adopts a multi-level perspective and frames the process of the creation, development and adoption of new pathways in three main dimensions or 'layers', the civil society, the institutional arrangements, and the economic landscape. Technological innovation and other 'new ideas' are seen to originate in the civil society 'layer' and having to gain support from the institutions. If they gain such support, they may develop and eventually new pathways may join or substitute old paths in the wider landscape. As explained above institutional co-evolution may be necessary so support can be put in place. The institutional arrangements are not static but are continuously re-evaluated and recreated or changed by agents. It is argued that institutions play a crucial role in filtering

agents' perceptions of technological change and changing circumstances. This may cause them to demand or enact changes of the formal institutional arrangements, leading to institutional co-evolution. Both formal and informal institutions are seen as influential. Informal institutions can provide access channels for new ideas because they influence agents' behaviours leading them to seek change and formal institutional arrangements may be so rigid that they prevent agents from enacting or even perceiving a need for change.

The following analysis of this study has two main parts. The first part describes the case of the development of the wind energy industry in Germany and Britain from a path dependency perspective structured in four phases as introduced via the conceptual framework. The second part analyses the role of institutions in the development of the wind energy industry in Germany and Britain structured along the key dynamics illustrated in the analysis framework.

2.6.3 Hypotheses

As a result of the literature review above and in order to make explicit the key insights from both the conceptual framework and the analysis framework two hypotheses are introduced.

2.6.3.1 Hypothesis I

Whilst the economic landscape naturally evolves in a path-dependent manner, institutions crucially impact on industrial development in one area over another because they filter how agents perceive technological development and changing circumstances and therefore either co-evolve formal institutional arrangements in support of new pathways or not.

2.6.3.2 Hypothesis II

a) Informal institutions can provide access channels for new ideas leading to institutional co-evolution because they influence agents' ways of thinking and behaviour and therefore impact on the ongoing process of evaluation of institutions by agents.
b) The formal institutional arrangements equally impact on the ongoing process of evaluation of institutions by agents because they influence agents' ways of thinking and behaviour. If they are too rigid and closed, new ideas are prevented from getting a foothold and institutional hysteresis continues. In contrast if they are open, new ideas can get established and the institutions are likely to co-evolve with technological development and changing circumstances.

The two hypotheses make explicit the focus of this study. Research Questions have been derived which will be introduced in the following Research Design and Methods chapter.

This chapter has laid out the key literature that this study is based on. The following chapter explains how from the above hypotheses and frameworks a set of research questions were derived and how this shaped the fieldwork. It will also provide information on the philosophical grounding of this study and explain which methods were used in the fieldwork period and why.

3 Research Design and Methodology

Research rarely goes according to plan, although this is not an argument against having a plan!

(Burnham et al., 2004, p.43)

3.1 INTRODUCTION

Following on from the discussion of relevant theoretical arguments and the illustration how they led to the creation of a conceptual and an analytical framework in the previous chapter, this chapter will explain how the conceptual framework was tested through application to the case of the wind energy industry in Germany and Britain. It is shown how the framework informed the choice of cases and methods.

The thesis focuses on the question why, despite similar starting conditions, the wind energy industry in Germany and Britain developed along different trajectories. It is argued that different institutional settings between countries or regions can explain such divergence because they filter agents' perceptions of technological development and changing circumstances and that both informal and formal institutions ought to be considered. The theoretical underpinning for this argument has been presented in the previous chapter and has been summarised in two hypotheses. These are reintroduced later in this chapter together with the derived research questions, which guided the fieldwork.

The particular view of reality and the understanding of what can be known and how it may be known influenced the design of the framework and the choice of methodology. They are presented in the first section of this chapter. This is followed by an explanation of the research design and focus. The objects of research are identified and the choice of cases is justified. The third section describes how the data collection was planned and compares this with what was actually done. The final section explains how data was collected, checked, coded and analysed, first in a pilot phase and then as part of the main fieldwork.

This chapter is followed by the first part of the analysis in chapter 4, which focuses on the path dependency of the wind energy industry development. This view is then expanded by a focus on the role of institutions in the fifth chapter.

3.2 PHILOSOPHICAL ROOTS

Ontology and epistemology provide the philosophical grounding for any research. Ontology refers to the researcher's position with regard to the nature of reality and how it can be investigated. Epistemology comprises the researcher's understanding of the nature of knowledge and of what can be known and how. The following section introduces the critical realist ontology and neo-realist epistemology and demonstrates how they are reflected in the conceptual framework.

3.2.1 Ontology

The study is based on a realist view of the world. Realists assume that there is an independent reality to human thinking. But they also acknowledge that this reality is produced and reproduced by people. They therefore refute pure empiricism. The world is not just what we experience through our senses, but these sensory perceptions are also deeply influenced by our individual experiences and background (Sayer, 2000).

Bhaskar (1979) suggests that social life consists of open systems and that closed systems are impossible in social life. Sayer (2000) postulates that urban and regional systems are necessarily open and not equilibrated, but that they evolve. This is because people have the capacity to learn and adapt their behaviour. Realists are interested in explaining change in open systems. Critical realists put the focus on necessity and contingency and on the way in which causal tendencies can produce quite different outcomes in different contexts. This may concern space (e.g. topography) or time (e.g. historical circumstances). This investigation of the effect of different institutional settings in two countries and the development of an industry in this context over a historical period clearly takes a critical realist perspective.

Realism attributes three layers to reality: the real, the actual, and the empirical. The 'real' includes any natural or social object that exists but includes its properties, structures, and powers (Sayer, 2000). The 'actual' contains what happens when the structures and powers of objects are activated and take effect. The 'empirical' describes the sensory experiences of individuals. This is summarised in Table 3.

Empirical	Perceptions, impressions, sensations
Actual	Events, states of affairs
Real/deep	Structures, mechanisms, powers/liabilities

Table 3: The three ontological levels of reality (Smith, 2003, p.299)

Where the empiricist is seeking to establish that a causal relationship is at play, the realist is concerned with the social structures which produce the observed patterns. Realists not only seek to identify these social structures but also understand them to be continuously (re)produced by human agency (Smith, 2003). Society, therefore, is condition and cause to human agency as well as reproduced outcome of it. Transformation (i.e. change) of a society is the result of the actions of (often unconscious but) skilled active subjects, rather than just being a mechanical consequence of a set of pre-conditions (Bhaskar, 1979). This echoes the positions on the relationship between structure and agency that have been introduced in the literature review. It relates to Giddens' structuration theory which urges a focus on both structure and agency and suggests an 'active view of agency' where agents' capacities are given full regard (Giddens, 1979; Giddens, 1984). It also echoes the view of mindful agents within path creation theory. Again, agents are constrained by pre-existing structure but they also have a capacity to deviate from given ways of doing things and can thus become 'path creators' (Garud & Karnoe, 2001).

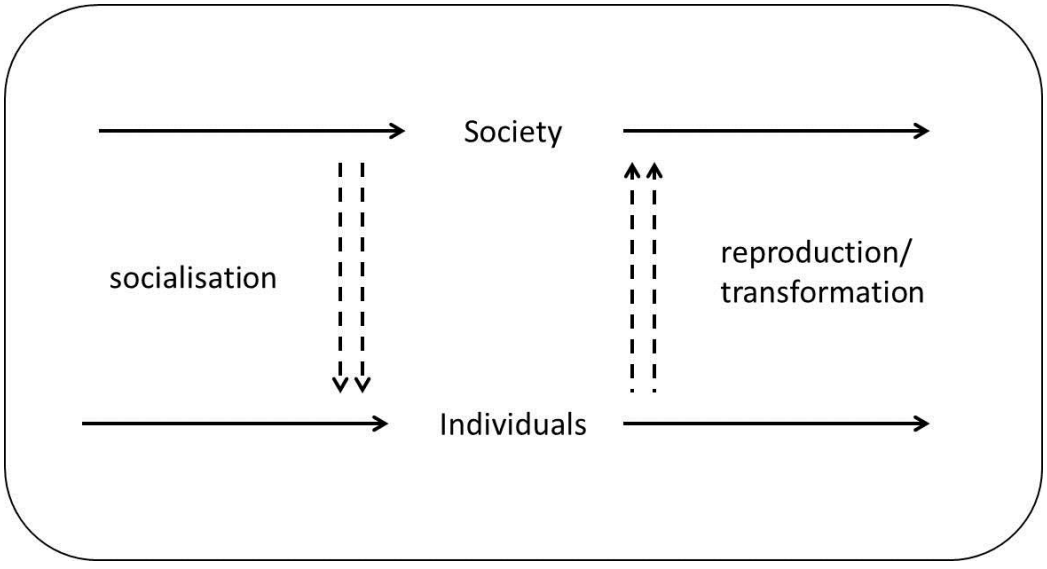


Illustration 5: Transformational model of the society/person connection (Bhaskar, 1979, p.46)

Illustration 5 on page 96 shows the relationship between human agency and social structure, a circular flow of socialisation of individuals who reproduce and transform society, which in turn socialises them and others again and so forth. This is reflected in the conceptual framework which describes a continuous flow of conditions, mindful path deviation and creation, path development, and outcomes, which will become pre-conditions for the next agents and so forth.

3.2.2 Epistemology

Epistemology describes the understanding of the nature of knowledge and of what can be known and how such knowledge may be acquired.

The epistemology associated with realist ontology is 'neo-realism'. Neo-realism postulates going beyond a mere description of regularities between phenomena or between events. It invites to "locate the structures or mechanisms that have produced the pattern or relationship" (Blaikie, 2007, p.22). Furthermore the neo-realist accepts that human beings' knowledge about the world cannot be absolute, it can only be 'tentative'. The knowledge that human beings can produce is deeply influenced by their preconceptions and any theories that they already hold about the world around them. Neo-realism therefore acknowledges the restrictions on humans' ability for 'definite representation' of an absolute reality (Blaikie, 2007, p.24). The likelihood that underlying structures will become effective powers in reality or 'actuality' depends on whether the circumstances are favourable to this. Also "realists emphasize the way in which structures can acquire a degree of solidity and apparent permanence, that we should recognize the legacy of the past in shaping our present concerns and desires" (Smith, 2003, p.305). This resonates in the evolutionary economists' focus on the role of historical events for the present conditions. Path dependency theory in particular puts a focus on the role of historical events.

The concept of science and knowledge in this study is grounded in the work of Thomas Kuhn (1962). In Kuhn's interpretation all science is 'of its time', which means that there is no such thing as timeless scientific enquiry. Kuhn conceptualises dominant assumptions as 'scientific paradigms', which define the range of activities that can be carried out, that are considered 'worth trying'. Following this view science evolves along the lines of periods of 'normal sciences' – routines, activities of 'puzzle solving' within existing paradigms – and scientific revolutions triggered by tensions between the problems at hand and their irresolvability through the existing knowledge and means of science. Kuhn believes that, as science progresses, 'old' paradigms may not fit 'new' circumstances.

He also suggests that they cannot adjust and change but that paradigms can only be substituted. As society changes the usefulness of one paradigm decreases and this, necessarily, leads to a 'scientific revolution' (Smith, 2003; Kuhn, 1962). He recognises the role of sociological processes in bringing about such revolutionary change (Epstein, 2012). Kuhn's work has inspired some of the theories of economic change which the theoretical framework is based on (e.g. the 'scientific paradigm' becomes a 'technological paradigm' in Dosi's (1982) work with reference to Kuhn – see literature review). It is reflective of the idea of the socio-technical character of technology, where a socio-technical landscape that is no longer appropriate to the level of technological progress is likely to be challenged and may have to change (i.e. co-evolve). The idea of co-evolution, however, allows for progressive change rather than suggesting necessary revolutionary change.

In summary the epistemology to this research puts the focus of inquiry on the discovery of underlying mechanisms and events from the past that have shaped the present state. It rests on an understanding of science and knowledge as being 'of its time' but also suggests that paradigms may change, i.e. co-evolve, with technological development and changing circumstances.

3.3 RESEARCH DESIGN

Burnham et al. (2004) introduce two basic models of looking at the research process – a linear model and a circular model. For reasons of clarity the process of this research was laid out using an extended version of the linear design as shown in Illustration 6 below. The advantage of this model is that it shows each step as a sequence and in a timely order. The research can thus be planned and an attempt at timing each phase can be made. The rest of this chapter largely follows this structure.

A more realistic representation may be achieved through a circular model which explicitly allows for the repetition of steps and for feedback loops, where new data suggests that hypotheses or research questions need to be adjusted (Burnham et al., 2004). Ultimately, however, any model of the research design can only be a vague approximation as it is impossible to capture in two dimensions the complexity of an actual research project.

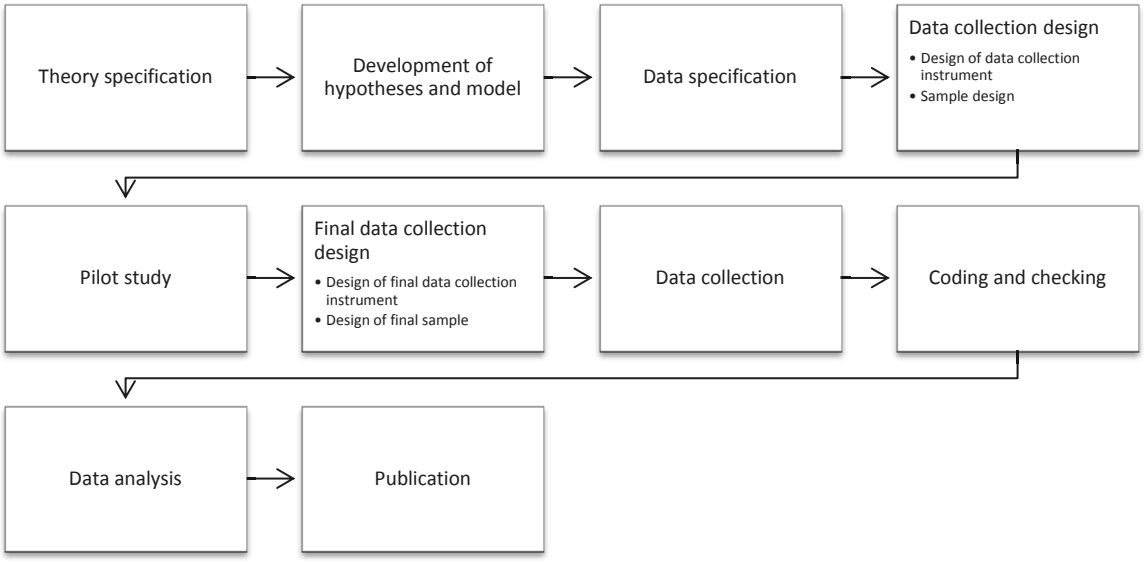


Illustration 6: The main stages of the research process as a linear progression (Burnham et al., 2004, p.43)

3.3.1 Use of Theory – Theory Specification

Theory specification was done through a literature review early on in the research process. A literature review is essentially a synthesis of as much of the existing literature as possible in the chosen subject area. Its exact character can vary, but in most social sciences modern studies will seek a cross disciplinary approach taking consideration of multiple perspectives (Hakim, 2000). This advice was followed and key theoretical arguments across the disciplines of economic geography, sociology, and politics were compiled. The literature review can be found in the 2nd chapter of this thesis.

This study applies a social science use of theory which typically means that the researcher establishes a theory which she places at the beginning of her study and which will guide her investigation including which methods she applies and how she will analyse the gathered data. A conceptual framework is created which informs hypotheses and a set of research questions. The study is concluded by a reflection on the initial theory, a statement as to whether and how the collected data has confirmed or falsified the hypotheses, and suggestions as to how the framework could be improved (Creswell, 2014).

3.3.2 Development of Hypotheses and Model

In line with realist thought the author followed a strategy introduced as 'retroduction' by Roy Bhaskar. It describes the use of reason and imagination to develop a picture or model of structures and mechanisms that are at the root of observed phenomena. The research objective is then to seek evidence for the existence of this mechanism. If there is sufficient evidence then the mechanism might explain an observed regularity. Whilst induction is usually described as a 'bottom-up approach' and deduction as a 'top-down approach', retroduction could be illustrated as a spiral approach in recognition of the non-linearity of the research process, full of feedback loops and numerous iterations (Blaikie, 2007). It is important not to conflate the testing of theories in a deductive approach with the testing of models in the retroductive approach. A deductive approach seeks to establish relationships between events or variables, whilst the retroductive approach seeks to establish the existence of the structure or mechanism that produces an observable regularity (Blaikie, 2000).

The conceptual framework represents the mechanisms of the relationship between new path creation and development and institutional arrangements, and the resulting changes in the economic landscape. This framework has been introduced as part of the literature review. A second analytical framework provides the focus on the inter-relationships and inter-dependencies between both formal and informal institutions. The analytical framework has been introduced at the end of the literature review. Two hypotheses were derived from the conceptual and analytical framework, which guided the further research. They shaped the research questions and the methods used to investigate them. Together the frameworks, hypotheses, and research questions enable the reader to understand the researcher's objectives and intentions at each stage.

3.3.2.1 Research Focus

The overarching research question to this study has been

Why did the wind energy industry develop earlier and to a greater extent in Germany than in Britain?

Whilst the conceptual framework and the analysis framework illustrate the underlying mechanisms at play, the two key hypotheses address the overarching research question:

3.3.2.1.1 Hypothesis I

Whilst the economic landscape naturally evolves in a path-dependent manner, institutions crucially impact on industrial development in one area over another because they filter how agents perceive technological development and changing circumstances and therefore either co-evolve formal institutional arrangements in support of new pathways or not.

3.3.2.1.2 Hypothesis II

a) Informal institutions can provide access channels for new ideas leading to institutional co-evolution because they influence agents' ways of thinking and behaviour and therefore impact on the ongoing process of evaluation of institutions by agents.
b) The formal institutional arrangements equally impact on the ongoing process of evaluation of institutions by agents because they influence agents' ways of thinking and behaviour. If they are too rigid and closed new ideas are prevented from getting a foothold and institutional hysteresis continues. In contrast if they are open new ideas can get established and the institutions are likely to co-evolve with technological development and changing circumstances.

3.3.3 Research Questions

Derived from these hypotheses and the framework the author put forward a set of research questions that served to focus the fieldwork element of this study. Blaikie (2000) emphasises the difference between research questions and interview questions. The research questions are posed in relation to what the study wants to answer as a whole, whereas interview questions are ways of eliciting particular information from respondents. They are different in style and scope. The language is more appropriate to the respondents

and the questions are focused around their experiences. Research questions may be answered by a wide variety of data, which is collected through fieldwork.

An initial set of research questions included a question on the particular role of 'bottom up' initiatives for the development of the wind energy industry in Germany. This line of inquiry was dropped following the pilot study, which consisted of interviews with four academics in the field. A closer focus on the role of institutions was developed instead. The final, comprehensive perspective does acknowledge explicitly the more 'bottom up' process of energy transition through a wide range of agents in Germany as opposed to the relatively 'top down' process in Britain.

These are the research questions that shaped the main fieldwork and in particular the questionnaires.

1. In what way did civil society agents and incumbent firms seek to influence the institutional framework in Britain/Germany? Why were they more/less successful than their British/German counterparts?
2. What was the key factor for the formation of more or less supportive institutional arrangements in either case country? To what extent did institutional inter-dependency between different scales and different types of institutions play a role?
3. How did new ideas in the realm of informal institutions impact on the perception of technological trajectories and changing circumstances by agents and in particular by agents within organisational forms of institutions?
4. Did the formal institutional arrangements restrict agents in their thinking and acting, in particular those within organisational forms of institutions? Did the formal institutional arrangements allow for new ideas to form amongst agents and in particular those within organisational forms of institutions?

3.3.4 Identification of the Objects of Research

In a next step the objects of research were identified. This was done using the conceptual framework, the hypotheses, and the research questions as guidance. The table identifies the objects of research. The first column shows the general objects of research identified from the theory. The second column shows what this meant specifically in the context of the development of the wind energy industry in Germany and Britain. And the third column

specifies the particular objects of research for this study. The table is structured along the conceptual framework and its 'layers', the industrial landscape, the institutions, and the civil society.

Theoretical objects	**Meaning for wind energy industry**	**Case-specific objects**
Industrial landscape	Electricity supply industry	Incumbent network and supply companies (incl. state-owned enterprises), established renewable energy companies
Formal institutions	Legal framework, technical infrastructure	European directives, Energy laws & feed-in tariffs, planning system
Organisational forms of institutions	Governance, QUANGOs	Successive governments on national, regional and local level, Carbon Trust, publicly funded research institutes
Informal institutions	Values, cultural norms, attitudes, beliefs	Attitude towards the environment and towards means of energy generation, perception of global threats
Civil society	Inventors, innovators, citizens and social movements	Inventors, green movement, anti-nuclear movement, community initiatives, energy co-operatives, citizens, consumers

Table 4: The objects of research

3.3.5 Data Specification – Choice of Case Studies

Burnham et al (2004) differentiate between the 'dependent variable' and the 'independent variable'. "Dependent variables are the phenomena that we want to explain in the research. Independent variables are the things we suspect influence the dependent variable" (Burnham et al., 2004, p.62). In this study the dependent variable is the 'industrial landscape development and its socio-economic outcomes'. The purpose is to identify and explain the creation and development of new economic pathways into a path-dependent economic landscape. The ascension of wind energy technology into this landscape produces changes in its characteristics. The independent variable is the 'formal and informal institutional arrangements'. The author recognises that there are a number of reasons for the development of the wind energy industry in Germany and Britain as this is a complex process and cannot be reduced to just two variables. For the purposes of

exposition, however, the heuristic device of defining a dependent and an independent variable has been applied to clarify the author's intentions.

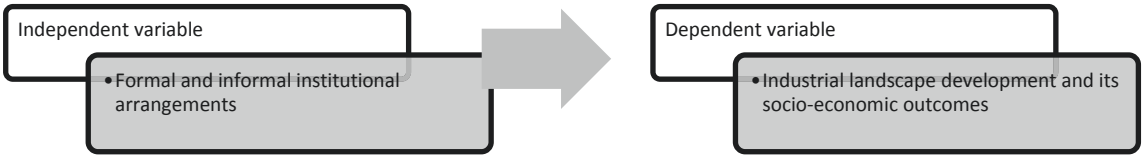


Illustration 7: Independent and dependent variable

In order to show that co-evolution of the institutional environment with technological development is a key factor for changes in the economic landscape, cases need to be chosen on the basis of where there were similar technological starting points but significant differences in the institutional environment, which are expected to have led to the divergence in pathways. This is a 'most similar' approach to choosing cases (Burnham et al., 2004).

Burnham et al (2004) emphasise the 'principle of not selecting cases on the dependent variable' which means that cases must show significant variance across the dependent variable. The countries for this comparison, Germany and the United Kingdom were chosen as they represent divergent industrial development in the wind energy sector. For example, as of April 2016 there were 17 active wind turbine manufacturers in Germany, whereas there wasn't a single one in the United Kingdom (Pierrot, 2016). In 2013 the German wind power industry provided employment for 104,000 people in onshore energy, and 17,800 people in offshore energy (O'Sullivan et al., 2014). The UK industry in comparison employed 9,911 people in onshore and 6,830 people in offshore (RenewableUK, 2013). Whilst the United Kingdom was the biggest installer of offshore wind turbines in the world in 2013 (Corbetta, 2014), all of these were produced by German manufacturer Siemens (RenewableUK, 2013). A summary of the wind energy industry in Germany and Britain by the Global Wind Energy Council for 2015 also shows that three out of the five main turbine providers in Germany are German and in Britain four out of five are German too (Global Wind Energy Council, 2015).

Initially it has been considered whether, for reasons of focus, a small number of regions within Germany and Britain should be chosen for comparison. The academics interviewed as part of the pilot study, however, emphasised that the most important

decisions that shaped the development of the wind energy industry in Germany and Britain respectively have been made on the national level. As a consequence the focus was kept mainly on the national level, although the inter-dependency between the different institutional scales is considered. The pilot study is explained in more detail below in section 3.4.3.

In terms of the institutional environment, preliminary research suggested very different preconditions in the two countries. Whereas there is a traditional strength of federal government as well as local and regional, strategic governance in Germany through local authorities and Länder, the local and regional government in Britain are much weaker in comparison. Since 1991 there have been attempts to strengthen the regional, strategic level through devolution of government offices as well as the establishment of regional strategies and bodies. The incoming coalition government of 2010, however, abolished most of the latter (leaving only the London assembly). Local units of administration in Britain are relatively less powerful and less well equipped financially than in many European countries including Germany. There are some exceptions including in the devolved countries Scotland and Wales and some of the city-regions in England (Allmendinger & Haughton, 2013; Cullingworth et al., 2015).

Electricity supply is traditionally undertaken on the municipal level in Germany, whereas Britain has been left with large, international providers structured based on previously existing regional supply structures. Recently Britain was able to 'catch up' on renewable energy development, which is mostly down to direct policy support of offshore wind. Britain seems primarily focused on reaching its targets in terms of a 'decarbonisation' of the energy industry – internationally agreed targets which also apply to Germany, but with the added burden of a commitment to a nuclear free future.

Overall it appears that from a similar starting point in the early 1980s Britain and Germany have both achieved remarkable progress towards an energy transition but that, instead of just being 'buyer' and 'receiver' of the relevant technologies, Germany has managed to lead the world in development for a period in time and thus reaped much wider socio-economic benefits. In contrast, after promising beginnings in terms of technological development, the wind energy industry in Britain was not sufficiently supported to flourish and survive. Thus the 'wind element' of the transition towards renewable energy in Britain only yields limited socio-economic benefits locally, regionally and nationally compared to Germany. The study is focused on why and how this divergence occurred. The wider question is whether the wind energy industry in Germany

and Britain is just an isolated case or whether there are underlying dynamics at play, which are equally relevant to other industries. May there be lessons to learn, which are transferable to other countries and regions?

So far this chapter has provided the philosophical grounding for this study and has shown how it influenced the conceptual and the analysis framework. The research design has been presented, the hypotheses have been repeated and the thus derived research questions were introduced. On this theoretical basis the objects of research have been defined and the particular cases studied for this thesis have been specified and their use has been justified. The following section will lay out the data collection design for the fieldwork element.

3.4 DATA COLLECTION DESIGN

From Table 4 above showing the objects of research it became clear that a mixture of methods would have to be used. The distinction is not clear-cut but formal institutions were mostly investigated using document study, whereas informal institutions required data on people's attitudes. These were approached through the use of quantitative data sources (e.g. data from existing attitude surveys). Agents on the different levels of the framework were spoken to directly to uncover their particular perspectives, motivations and strategies.

Creswell (2014) acknowledges that the distinction between quantitative and qualitative approaches cannot be clear cut and often a study will contain some ambiguity. This study is more qualitative than quantitative due to its critical realist concentration on the explanation of underlying dynamics. Creswell (2014) suggests a useful third category – mixed approaches – which incorporates elements of both, based on the idea that this is more comprehensive than simply a quantitative or a qualitative approach. This study applies an explanatory, sequential mixed methods strategy. The results from the second, qualitative element explained and expanded on the results from the quantitative, descriptive stage. The purpose of the quantitative analysis of a small set of indicators was to illustrate the research problem and to demonstrate the presence of processes with real, socio-economic impact. The aim of the qualitative research element was to uncover some of the mechanisms that led to the actions which produced those effects. Overall the main emphasis was on the results from the second, qualitative research element as this was expected to produce a rich picture of the development of the industry from the direct experiences of a broad range of agents across the 'layers' of the framework.

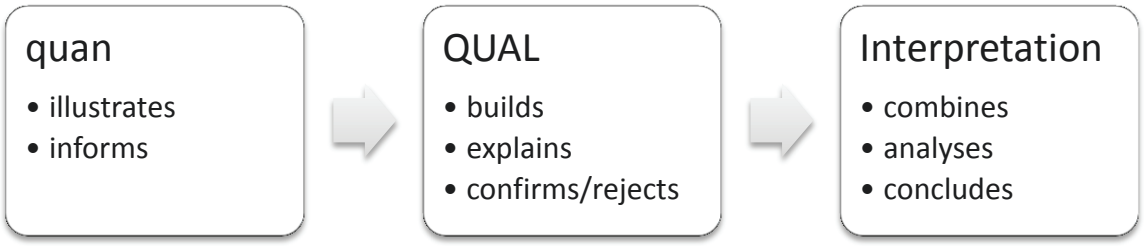


Illustration 8: Sequential, explanatory, mixed methods research design based on Creswell (2014)

3.4.1 Quantitative Research Element

Reflecting the conceptual framework, three types of quantitative data were collected: Data which represents innovation activity, the extent of diffusion, and the socio-economic outcome for the consumer of these processes. Data collection was more difficult than expected as there is limited availability of data to enable a reliable comparison across the two countries. In many instances the study relied on Eurostat data provided by the European Commission, where data collection methods across countries tend to be the same or very similar, but unfortunately sometimes potentially interesting data was not available for either or for both countries. The actual data that has been used to illustrate each phase is shown in the right column of the table below:

Types of Data	Actual data
Innovation	Company entry and exit
Diffusion	Installed wind capacity, primary electricity production from wind
Socio-economic outcomes	Electricity prices

Table 5: Types of quantitative data

To illustrate the evolution of the wind energy industry in Britain and Germany the entry and exit of companies into the wind industry was used. This serves as a proxy for 'innovative activity'. Whilst initially patent data was analysed, this was found to be insufficient as it does not represent the building of the industry but only the immediate 'inventive activity'. Furthermore, it has become clear that in terms of inventive activity there is little difference between the two countries. Figure 3 presents a graph which shows the wind power related patent applications as a share of total patent applications in the two

case countries between 1978 and 2012. Perhaps somewhat surprisingly, both countries show similar rates of invention in terms of wind energy technology when put in relation to the total number of patents (OECD, 2013).

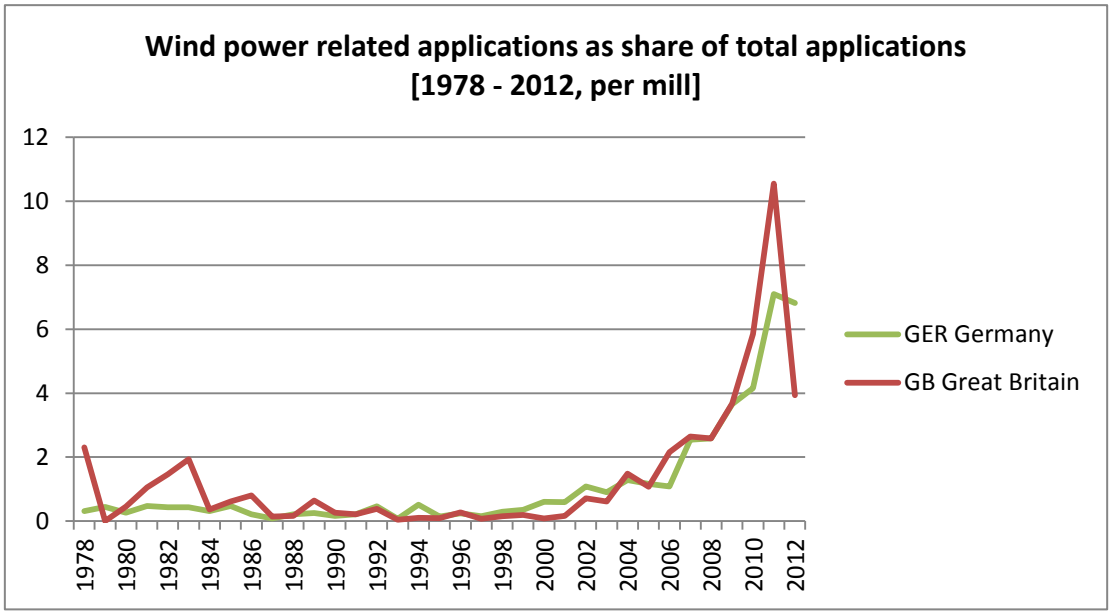


Figure 3: Wind power related applications as share of total applications, OECD (2013)

Essletzbichler (2012) reports similar findings from a sophisticated quantitative analysis where the levels of patenting activity in English regions are similar to those in German regions when controlled for population size or total patent activity. These similar rates indicate that the divergence lies in the building of the industry and therefore in the development of paths rather than in the creation of pathways. The entry and exit of companies into the industry was therefore found to be a better indicator. Data was kindly provided for free for academic purposes by the commercial online wind market intelligence provider thewindpower.net. Most companies were presented with an entry and an exit year. Where the database was incomplete the gaps were filled through internet research as far as possible. As a matter of courtesy, the additional dates were then fed back to the provider so he could add them to the database. The data was arranged in an MS Excel workbook so as to create a graph that showed a time line of entry and exit of all German and British companies in the database. The graph lists 37 German and three British companies. It is not entirely exhaustive but still provides a good overview of the development of the industry over time.

To illustrate the spread of the wind energy technology the cumulative installed wind capacity in each country is shown. Data on the electricity produced, measured in tonnes of

oil equivalent, has also been acquired. This gives a better indication of the actual impact and acceptance of the technology in the two countries. The first graph is based on data that has been obtained from the German wind energy association, the Bundesverband Windenergie (BWE), and combined with data from the Department of Energy and Climate Change (DECC) in Britain. The data for the second graph has been obtained from the Eurostat database by the European Commission. All three are public online sources and so access was guaranteed.

Finally one of the socio-economic impacts of wind technology diffusion, the electricity price, is shown. This is done in several parts. One graph shows the total price of electricity for household customers for Britain and Germany. This is compared with the price for the energy and supply for both countries. A third graph shows the shares of the price components, energy and supply, network costs, and taxes and levies, for each country. All the data has been obtained from Eurostat which allows for reliable comparison across countries. The data is free and publicly available online. Unfortunately, no reliable longitudinal data on employment numbers from the wind energy industry in both countries could be found.

The full comparison of these quantitative indicators can be found in the first part of the analysis in chapter 4.

3.4.2 Qualitative Research Element

The main element of the qualitative research element for this study was a total of 36 in-depth interviews. The information from these interviews was relied upon to build a coherent story. In order to 'thicken the plot' comments from the interviews were also used as 'signposts' towards further data and evidence. This includes the study of documents, numerical data, and of a wide range of literature like biographical accounts and academic work on similar subjects.

3.4.2.1 Document Study

The term document study refers to the study of written sources. Burnham et al (2004) distinguish three main groups of document sources:

1. Primary sources are evidence that was part of or produced by the event that is being studied.
2. Secondary sources are material that has been circulated at the time or soon after the event and was available to the public at the time.

3. Tertiary sources are all later work which offers a reconstruction of the event.

They recommend that the use of secondary and tertiary sources, whilst perfectly legitimate, must be backed up with elite interviewing and ideally the use of some primary sources.

This study triangulates all three types of document sources. For example some of the original legal texts are referred to (e.g. Stromeinspeisungsgesetz of 1990 – primary source), newspaper articles are quoted (e.g. advertisement from Die Zeit from 1993 – secondary source), biographical accounts are being used and academic work on the matter at hand (e.g. Porter (2014); Lauber (2012) – tertiary sources). This was combined with the main data source, the 36 in-depth interviews, as explained above. Such triangulation helps to gain a more comprehensive view of the matter at hand. Arguments that are backed up by data from a number of different kinds of sources are stronger than those that rely solely on a single source. The analysis chapters seek to support each argument that is made with a number of different sources.

3.4.2.2 Attitude Surveys

Access was gained to a number of attitude surveys carried out across Europe and further countries in the world by GESIS at the Leibniz Institut für Sozialwissenschaften based in Köln and Mannheim in Germany. This data is available online and free for researchers following registration. It is provided in the form of an SPSS database and questionnaires either online or in pdf documents. The two data streams used were the European Value Study (EVS) which provides longitudinal data for most questions in one single SPSS file and the International Social Survey Programme (ISSP) which provides data in separate SPSS spreadsheets. Data for Germany was descriptive of the state either before or after unification, which had to be accounted for through the application of weights for data at the relevant points in time. The author gained the information on how to apply weights and which weights to apply from GESIS' online pages and via email from very helpful contacts at the organisation. A cross-tabulation in SPSS then provided the needed data for each country and by survey year in tables. These were visualised using graph creation functions in MS Excel.

3.4.2.3 Interviews

A total of 36 interviews were carried out with respondents across the two countries by the author. The technique used is referred to as 'elite interviewing' by Burnham et al (2004). They recommend this technique when talking to decision-makers or, more generally defined, where the balance of knowledge is in favour of the respondent.

The interview style was a semi-structured or standardised open-ended interview. Where the working and sequence of the questions were determined in advance and all interviewees were asked the same questions in the same order. Questions were worded in an open-ended format (Teddlie & Tashakkori, 2009, p.229). Different types of respondents were approached, looking for a cross-section of people that have good knowledge of the industry. Interviews took approximately one hour per respondent and were carried out face-to-face where this was possible. Overall about a third of interviews had to be carried out using Skype or the telephone. Bryman (2001) advocates, that telephone interviews or interviews by internet telephony are acceptable alternatives, where interviewees are abroad or spatially dispersed and where there is time-pressure on the researcher. The author sent an invitation email to potential respondents (a sample can be found in appendix 8.1). Respondents got back and indicated their preparedness to help in principle. According to the ethics protocol the information sheet was then sent and a suitable time and place was arranged. At the actual interview respondents were asked whether they had read the information sheet and were given an opportunity to do so if they had not. They then signed to confirm that they had read the information and that they agreed to be interviewed and recorded. All respondents agreed to this so all interviews were audio-recorded. They were transcribed afterwards and they were analysed using the qualitative analysis software NVivo.

3.4.2.4 Sample

Four types of respondents were defined and it was expected that it would be possible to compile a sample frame that would be relatively representative of the total sample (as in the total of relevant experts). In the event this strategy did not come to fruition because sources of information on this are very dispersed which makes it difficult to even get a sense of the complete sample. After a period of uncertainty the strategy which transpired as most useful was to approach a small number of contacts acquired from relevant sources and then to use snowballing or the 'referral technique' to get to further contacts. This is a process whereby the researcher asks existing respondents and everyone she approaches for

further or alternative potential contacts (see invitation letter in Appendix 8.1). A potential risk is non-collaboration by respondents where they are not prepared to help. In fact all respondents were exceptionally helpful and resourceful. Some actively encouraged their colleagues to get in touch with the researcher as they shared an interest in the research. A further important issue is the potential skewing of the sample towards certain cohorts. To some extent this occurred where a number of former wind energy engineers from Wind Energy Group in Britain were interviewed. But overall a wide range of interviewees was achieved, with agents from all layers of the framework. Burnham et al. (2004) warn that it is important to realise when to stop when using the snowballing technique. This issue was obviated by constantly reviewing the number of respondents and the notes made immediately after interviews whilst in the fieldwork process. This helped the researcher to notice when a point of saturation had been reached, meaning that further interviews were unlikely to yield further insights.

The four types of respondents that were defined are described in the following section (following the pilot study this was simplified from a previous version):

3.4.2.4.1 Experts

are people that have previously done similar research or are very knowledgeable in the field of innovation in wind energy technology. Most have insights across the two countries. Experts were only approached for the pilot study, for which four key academics were interviewed. They were able to provide a good overview of the industry. Most tended to have better insight of one or the other country. A good balance was achieved across both countries and two academics were interviewed in Germany and Britain respectively.

3.4.2.4.2 Civil Society Agents

are members of the civil society who promote the use of a novel technology because it furthers their interest. This includes both a wider societal interest, for example the concerns of climate change, or of power devolution in the literal as well as in the figurative sense, and individual interest like the fascination with a technology by an engineer. The sample included a mixture of both individual inventors and supportive innovators/entrepreneurs (those who seek to bring an innovation onto a market). A number of respondents were both inventor and entrepreneur at the same time. Initial contacts were identified through online research and secondary literature. They led to further contacts via snowballing. Individuals were targeted due to their inside knowledge of the early stages of the wind energy industry, many had been key decision makers in its development themselves.

Civil society agents also include engaged citizens that felt committed to a cause (e.g. environmental). They became activists and sought to gain influence on the institutional arrangements individually or collectively organised within social movements. Again, existing literature and online research pointed towards influential organisations that were approached. Further contacts were obtained through snowballing. Individuals were chosen because of their inside knowledge and personal experience of relevant social movements at the time. This could be either as close observers or because they had held important positions in influential organisations.

3.4.2.4.3 Institutional Representatives

are people that are or have been employees of organisational forms of institutions on the local, regional, or national government level, and are or have been witnesses of institutional change. Employees of quasi-non-governmental bodies also fall into this category. These agents tend to know the internal workings of organisational forms of institutions well and are therefore very interesting to speak to in relation to institutional change.

3.4.2.4.4 Incumbent Firms and Large Businesses

are agents that act on behalf of the incumbent industry or any large, established company. In the earlier phases of the development these are mainly the incumbent utility companies, whereas towards the later phases, as industries mature, what used to be 'bottom up' agents become part of the economic landscape. Whilst it was initially planned to approach the incumbent industries, an extremely low response rate led to the amendment of the strategy and current large companies in the wind sector were approached instead, which yielded better results.

It is important to plan which types of respondents to approach and to keep a record of how many people of each type have been spoken to in order to prevent bias of the outcomes. It was found, however, that most people did not fit into one or another category very clearly. As was explained before in relation to the conceptual framework, although 'layers' were defined, reality is not as neat and agents will often take more than one role in society or have experience that cuts across the 'layers'. For example a number of respondents were inventors in an early challenger company and had later gone on to work for a large company. Some were inventors but also activists. Two individuals were initially civil activists for renewable energy but became institutional representatives. Whilst this

made it difficult to categorise respondents it was beneficial for the study overall because of the richness of experience that could be accessed via the respondents.

Below is a table that compares the intended sample numbers against what was achieved. Since it was found that individuals did not fit into categories no distinction is made between the categories for the total numbers of respondents but instead the total number of interviewees for each country is shown. Difficulty was experienced in getting access to current and former politicians and civil servants in Britain. The smaller number of interviews was compensated for by using autobiographies and other academics' work as sources to understand British political dynamics. Even though the respondents are shown as to their country of activity, they also had differing levels of experience around both countries. Some respondents were only able to talk about their experience in one country, whereas some had a lot of experience of both countries and were able to compare processes. Overall a satisfactory range of perspectives of the wind energy industry in Germany and Britain was accessed.

	Germany		**Britain**		**TOTAL**	
Perspectives	**planned**	**actual**	**planned**	**actual**	**planned**	**actual**
Civil Society	5	16	5	15	10	31
Institutions	5		5		10	
Business	5		5		10	
Academia	2	2	2	3	4	5
TOTAL					**34**	**36**

Table 6: Planned vs actual numbers of respondents

3.4.3 Pilot Study

A pilot study was carried out as part of this research in order to gain initial experience around both the content and the methodology for the main fieldwork. The pilot study precedes the main fieldwork period as it is used to get 'feedback' on the study design. Following the pilot study changes may be made to the study design for the main fieldwork. A pilot study is not mandatory but can serve a number of purposes (Burnham et al., 2004):

1. It can reveal 'bad questions'. Questions that are inappropriate or that interviewees struggle to understand can be filtered out or changed.

2. Open-ended questions can be changed into closed questions if only a limited number of responses is given.
3. It can reveal potential new issues that the researcher has not previously considered and the need for further questions or a chance to shorten the questionnaire.
4. For the researcher themselves it can be a way of rehearsing interviewing and understanding the 'flow' of the questionnaire.
5. It assists in checking the sample frame and assessing the achievability of the task.

The pilot study for this research consisted of four expert interviews of varying length and the study of a small number of relevant documents. The pilot interviews were conducted in January and February 2015 and produced a total of eight hours of audio recordings.

An additional source of data was a total of twelve interviews with inventors and innovators in Germany and Britain. This had been part of a collaborative research project between Oxford Brookes University in Britain and Leibniz University Hannover in Germany on the divergent development of the wind energy industry in the two case countries with a particular focus on path creation and niche environments (Carpenter et al., 2012; Simmie et al., 2014).

The information gained from the pilot study has influenced this research strongly in both methodological and content related aspects. Following transcription an in-depth analysis of the interview material was carried out, which resulted in a written up summary of the preliminary findings. This shaped the author's understanding and resulted in changes to the conceptual framework, which has been introduced as part of the literature review. Comments from the expert interviewees led to a reinforced focus on the role of national institutions as it was stressed that the main institutional changes that led to the divergent wind energy industry development were introduced at the national level.

It was found that further interviews needed to be more focused and shorter. The total number of expected interviews was also reduced and the groups of respondents simplified (see section 3.4.2.4 above). With a view to the improved framework it was decided a good spread across the categories 'civil society', 'institutions', and 'incumbent firms/business' should be sought. This represents the three levels of the framework. In

reality individuals could not be categorised quite as neatly but a good range of perspectives was covered in the interviews.

The pilot study led to an improved framework and to an improved, more focused questionnaire. The process has thus been useful overall.

3.5 DATA COLLECTION

The previous sections of this Research Design and Methods chapter mainly concentrated on the planning stages of the research process. The following section explains the actual process of data collection and reflects on challenges that were experienced in this period. It also explains how the data was prepared for analysis and how it was eventually presented.

The main fieldwork period consisting of 32 elite interviews ran from 7th March to 5th November 2015 and therefore took a lot longer than intended. Progress was slowed down by the difficulty of gaining access to interviewees and coordinating with people's busy calendars. Fortunately other parts of the research could be progressed in the meantime.

Bryman et al (2004) define getting access to interviewees as one of the key challenges in elite interviewing. Governmental bodies can be difficult to reach, whereas non-governmental bodies are more likely to be open to be interviewed as they seek to get their message across. Difficulty in accessing individuals with inside knowledge of organisational forms of institutions was experienced in Britain especially. It is important to identify the right person to be interviewed which requires careful preliminary research using secondary documents and websites. One common experience is that a greater number of people are initially contacted than will eventually agree to an interview or even just respond to the initial contact. It takes perseverance to get interviews. Once a contact had been established a series of questions like "Who would be the person best placed to speak about X?" helped to identify the best person within organisations. As was pointed out above, many contacts were acquired through a referral process which was helpful as it removed the difficulty of finding out who to speak to and gaining access. This approach gave the researcher a remarkable level of access to some very important agents in the wind energy scene, for example the founder of one of the largest consultancies in wind in the world or a former senior civil servant. Sharing an interest in the subject of the study, respondents would often suggest further people to speak to and establish contacts with them.

Initial contact with interviewees was sought by sending an invitation email (see Appendix 8.1). Upon a preliminary declaration of interest the information sheet about the research was sent and formalities were explained. Interview times appropriate to both the respondent and the researcher were agreed and whether the interview would be carried out in person or via the telephone.

The interview was then carried out in a convenient place, ensuring little background noise, and having established that all necessary equipment worked as expected. Interviews were recorded, having sought permission from the respondent. Unfortunately a quiet room could not always be secured. On a small number of occasions outside locations were preferred which sometimes led to difficulty when transcribing the interviews.

The interview itself was opened by establishing the formal requirements (recording, participant information sheet, signing of consent form) and a verbal explanation of what the research is about. Then the interviewee was asked to explain their relationship to the wind energy industry. This was followed by a more specific or critical part and a conclusive question towards the end. The interview was finished by asking the interviewees whether they had anything to add or whether they had suggestions as to whom else to approach for an interview. This structure worked well in the pilot interviews and was carried forward to the main fieldwork. The interview guide for the pilot phase and for the main fieldwork phase can be found in Appendix 8.4 and 8.5.

Throughout the interview the researcher must listen carefully in order to be able to probe for further information or clarification where this is necessary. She must also be prepared to find unexpected information or views that challenge those of her own. She must ensure not to dominate the conversation, but to "let the respondent's voice come through [as i]t is their perception of the situation" that can be accessed through this kind of interview (Burnham et al., 2004, p.216). The interviewees' perspectives and positions were listened to carefully, but control of the course of the conversation was maintained. Sometimes it was necessary to bring respondents back to the subject. But on occasion it was beneficial to take a gentle approach, join in with a tangential conversation and then refocus the respondent. By doing this the trust of interviewees was gained and they were noticeably more prepared to share detailed information and to speak openly.

All qualitative interviews were transcribed during and after the interview phase. They had been recorded and the transcription was aided by transcription software which enables the transcriptionist to slow down and play back the recording. Listening to the

recording once before transcribing helps to make an educated decision about whether to include everything that has been said in a transcription (Bryman, 2001). All interviews were transcribed verbatim except for tangential passages as explained above. Software was used to slow down the recording and play back passages that were difficult to understand. Having finished a raw version of the transcription the recording was listened to again at full speed trying to fill any gaps and to make corrections where this was necessary. Undertaking this process meant that each interview was listened to at least twice. This is a time-intensive process but it also means that the researcher gains thorough knowledge of the data.

3.5.1 Checking and Coding

The finished transcriptions were sent to respondents who were given an opportunity to read through the transcript and to fill any gaps, make changes and add further information. All respondents agreed that the transcription was an accurate record of what had been said. Some were able to fill gaps, where information was not understood due to the quality of the recording or where there was a misunderstanding. A small number of respondents used the opportunity to add further information which they felt was important.

Bryman (2001) does not recommend leaving the analysis of data to after all interviews have finished and have been transcribed but to make this an ongoing activity. This ensures that emerging themes can be recognised and included. Immediately after the interview the researcher should review the notes that they have taken during the interview and make clarifications whilst the interview is still fresh in their mind. It is important for the researcher to be reflective and self-evaluate: What has worked well, what hasn't? This can inform further interviews and, especially following a pilot, the interview schedule may still be amended, which was the case for this study. Notes were constantly reviewed, not least to make sure to stop when saturation was reached as explained above. This information was also used to ensure appropriate emphasis was placed on certain parts of the interview with further respondents and on occasion to compare and contrast differing viewpoints directly (anonymised) with each other.

In advance of the actual analysis a 'write-up' of the story, which started to emerge based on all the notes from the interviews, was carried out. This led to the creation of another framework which defined the inter-relationships between different kinds of institutions in more detail and focused the study on the role of both formal and informal institutions. This analysis framework can be found at the end of the literature review in chapter 2 section 2.5. The analysis itself was carried out through a 'coding' technique using

the qualitative research analysis software Nvivo. The programme essentially assists the researcher in tagging and filtering their material, a process which would have been carried out manually before. It also has automated functions where words or groups of words can be searched for and coded. It provides cross-tabulation functions and offers some basic statistics on the qualitative data (Bazeley & Jackson, 2013).

A 'coding frame' was developed, a list of themes which was expected to be found in the textual material. The material could then be coded accordingly. Initially this coding frame was derived from the conceptual framework, reflecting the theory-led nature of this study. As new themes arose from the data material itself, however, the coding frame evolved throughout the analysis. The final version of the coding frame can be found in appendix 8.8 at the end of this study.

Nvivo does not take the cumbersome process of deciding paragraph by paragraph what themes are being covered away from the researcher. Although this means that the researcher remains firmly in control of the data and its interpretation, the quality of the analysis is restrained by the capacities of the human being. This means that the quality can even be impacted by small factors like the daily constitution of the researcher. It is also dependent on the particular researcher that carries out the task - a different person may interpret a text passage differently. It is important that the researcher keeps these factors in mind when analysing her data. Even if the actual coding is carried out with utmost consistency, language is highly nuanced. And therefore the mere fact that a text passage has been coded in a certain way does not mean that all these passages can be interpreted in the same way. The conclusion for the interpretation of data from Nvivo must therefore be that statistical results may be understood as indicative but must not be taken as definite results. They require contextualisation and triangulation with other ways of providing evidence. If this is done carefully then they can make an interesting contribution to a thorough analysis. This has been done for this study and can be found in the 2nd part of the analysis in chapter 5.

Considering the above caveats the researcher did find working with the qualitative analysis software very useful. Above all else it forced her to read through the interview data extremely carefully. Two very useful techniques used upon recommendation by Bazeley and Jackson (2013) were to use a code for 'quotes' and one for 'signposts'. Coding for 'quotes' alongside reading the texts was helpful, because at a later point they could easily be found in the material. Furthermore 'signposts' was a code given, where respondents made useful suggestions or recommendations. Again, this could be found easily later and all

recommendations could be followed up systematically. This led to the inclusion of many useful further data sources.

3.5.2 Data Analysis

The interview part of the main fieldwork as well as the study of further documents yielded a great amount of interesting data. The analysis framework helped to work through this data in a systematic way. Sets of questions were derived from each part of the framework. These were answered making use of the immediate interview data. Then the potential implications for theory were defined. This was a first step and does not form part of the final analysis.

The interview data was coded as explained above. The codes therefore contained a number of text passages. To compare different aspects like for example the role of different formal or informal institutions the relevant codes were compared to each other. This is to gain an indication of the importance of different aspects to interviewees. The amount of text coded to one category as percentage of the total interview text was calculated for each interviewee. Then an average was taken across interviewees for each relevant code and a graph was created to illustrate this. It is important to consider that the numerical data that can be produced using Nvivo is not comparable with the apparently exact nature of numerical data in quantitative analysis. This being qualitative analysis the material is textual and the actual interpretation is to be established by the researcher through the detailed study of meaning and context. As part of a careful triangulation this data can nevertheless make a contribution towards a thorough analysis.

Apart from the analysis of 'average percentage coverage' further analysis of the qualitative data was carried out using text search functions in Nvivo. It was found that it is insufficient to just compare data between German and British interviewees as they often shared experiences from both countries. So to enable the comparison between the two countries a proxy was found: Nvivo word searches for 'deutsch'/'german' and 'brit'/'engl' respectively were carried out and the surrounding paragraph was included. All this text was coded for 'Germany' and 'Britain'. These codes were then used to cross-tabulate with other codes and compare results. These tables were exported into MS Excel and the differences were visualised either through conditional formatting in the table itself or via graphs. The important caveats for this kind of numerical data produced by Nvivo have been explained above.

A further tool that was used was the search for most common words. The same process as for the two countries was carried out for particular politicians (Hermann Scheer: 'scheer'; Margaret Thatcher: 'thatcher'). Then a search for the most common words in these codes was carried out. The resulting table was exported and an online tool was used to create a word cloud. In the case of the search results for 'scheer' they were also translated so as to provide consistency within the analysis chapter. Similar word clouds were produced for some of the existing codes like 'informal institutions' or 'formal institutions', but the results were not found to contribute anything to the analysis.

Based on all this the final analysis was developed. It is presented in two chapters. The first part utilises the conceptual framework to structure an analysis of the path dependent evolution of the wind energy industry in Germany and Britain. This can be found in chapter 4 and is mainly historical in character. The second part utilises the analysis framework to provide detail on the inter-relationships and inter-dependencies between different kinds of institutions and their role for the development of the wind energy industry in Britain and Germany. This is presented in chapter 5 and is structured according to the different dynamics that are identified in the analysis framework.

The Research Design and Methods chapter reiterated the hypotheses and research questions, having introduced the philosophical grounding for this thesis. It was then shown how the objects of research were identified and appropriate cases were chosen. This was followed by a description of the data collection design, where it was shown that a descriptive, quantitative research element was expanded and built on by an explanatory, qualitative research element. This was the main focus of this study. Information from a range of sources like documents, surveys, and interviews was triangulated to support an argument. Finally further information was given on how the interview data was analysed and used both as immediate evidence and as signposts towards further interesting sources.

The following chapter will present the first part of the two part analysis chapter. Chapter 4 analyses the development of the wind energy industry in Britain and Germany from a path dependency perspective. The second part in chapter 5 will expand on this by focusing on the role of institutions for the development of this industry in the chosen case countries.

4 Analysis I: The Path Dependent Development of the Industry

4.1 INTRODUCTION

The following two chapters present the analysis part of this study. It will be argued that, starting from similar technological capacities and subject to the same external shocks, the British and German wind industries evolved along different pathways because their organisational, formal and informal institutions were different and consequently their co-evolution with the emergent technological pathway was also different. The outcome is a fundamentally different industrial development of the same sector in both countries. Whilst new entrants were able to challenge existing power structures and dominant pathways in Germany the energy system continued to evolve in a path-dependent fashion in Britain. The consequence is a diverse wind energy sector in Germany, which can provide for every part in the supply chain including the turbine itself. In contrast in Britain the sector is dominated by large, often foreign directed companies and key parts like the turbine itself need to be imported from elsewhere.

This chapter describes the development of the wind energy industry in the two case countries from a path dependency perspective in phases with reference to the conceptual framework of this study. The phases are

1. a 'preconditions' phase where the circumstances against which new paths may be formed or old ones may persist are understood to have their origins,
2. a 'new path creation' phase where new technological paths may be formed and need institutional support,
3. a 'path development' phase where the newly formed paths either continue to develop, having gained support from the institutional arrangements or fail because they have not gained such support.
4. Finally a 'consolidation and outcomes' phase where the technology has matured and the industry is built with socio-economic outcomes and changes in the economic landscape.

The energy industry is shown to evolve in a fundamentally path-dependent fashion but the constellation of institutions has a crucial impact on how agents perceive and act on technological development or changing circumstances. This is explored in detail in the second part of the analysis in the next chapter.

4.2 PRECONDITIONS

The conceptual framework describes the pre-conditions phase as that of 'pre-existing institutional arrangements' shaped by previous events and agents, that may be supportive of new paths or not. The second part of the analysis will focus on how inter-institutional relationships shape these institutional arrangements.

The destruction and despair of World War II may be understood in the terms of path dependency theory as a strong external shock that may cause pathways to be disrupted. Despite the fact that both countries underwent a similar shock Germany and Britain found themselves in very different situations. Germany had suffered defeat in war and had to develop a new role as a nation living in peace with its neighbours. Safeguards to prevent the kind of power imbalance that caused World Wars I and II were put in the new constitution for the country. Germany was to be a federal state, giving considerable power to subnational administrations. Meanwhile, Britain came out of the war 'victorious' with less of a notion that there was any need to change power structures and so many of the long established elites were able to carry on as before (Childs, 2001; Glaessner, 2005; Giddens, 1974).

The internal composition of the electricity supply industry in Britain was significantly changed in 1948 when it was taken into public ownership to be governed by the Central Electricity Board. This meant that the much smaller scale structures that had existed previously disappeared and the industry was focused on the use of coal as its main resource for electricity generation. Monopolistic structures were not only allowed but encouraged to develop. This created vertically integrated structures for each energy form and minimised penetration by other influences, including government (Taylor, 1996; Simmie et al., 2014; Childs, 2001). The German electricity industry differed significantly from the industry in Britain as its structure was much more varied. Besides the network companies (Verbundunternehmen) there were also the regional electricity suppliers, responsible for the nationwide distribution and the municipal utilities (Stadtwerke), providing power to consumers in regions where neither supplier was available (Simmie et al., 2014).

Across Europe there had been a significant tradition in harvesting wind for agricultural use. The patent for the use of wind energy for the generation of electricity was first granted to Prof James Blyth in Scotland in 1891 (Gipe, 1995). Similar to the Netherlands it had been necessary in regions of Northern Germany to build and maintain

dykes to make them inhabitable. This was organised entirely by the community in a self-managed fashion before 1900 when it was taken over by the state. Interviewees see a strong influence of this experience of self-organisation and co-operative management on the later development of decentral provision of renewable energy and high rates of citizen ownership of energy generation plants.

From 1900 the dyke construction was taken over by the state, before that it had to be organised privately. Dykes a hundred years ago were not as high, but they still needed to construct dykes, they needed to get organised. They needed a kind of self-management. […] therefore there has always been a high level of self-management in this area and this mentality is still noticeable today.

(interviewee G2)

The increasingly tense situation in the Middle East, the Yom Kippur war and demands of higher prices by the Organisation of Oil Producing Countries (OPEC) caused a considerable shock to the Western world, which became known as the oil crises of the 1970s. The Yom Kippur War led to a fourfold increase in the price of oil in 1973. This shook the global markets and many countries re-focused utilities towards coal and nuclear energy, crucially reinforcing these existing pathways (Musgrove, 2010; Childs, 2001).

Contingent factors like a number of high profile nuclear accidents, especially that at Three Mile Island, US, in 1979 and that in Chernobyl, Ukraine, in 1986 acted as external shocks which spurred on an anti-nuclear movement which increasingly joined forces with the peace movement to form a global environmental movement. Throughout the 1990s climate change and its potentially disastrous consequences were increasingly recognised by the international establishment leading to ever greater pressure from supranational institutions on the national governments to take action. Importantly the United Nations Framework Convention on Climate Change officially recognised in 1992 a) the man-made nature of climate change and b) that man-made GHG emissions are a significant cause of it. What followed were commitments and targets on supranational and national levels through what is known as the Kyoto Protocol in 1998 (United Nations, 1998).

In 1992, for the first time, the European Community set a target for the development of wind energy in Europe. 8000 MW were to be installed by 2005 (Gipe, 1995). 10 years later the EU Directive on Electricity Production from Renewable Energy Sources, taking effect in 2001 set out national targets for rates of renewables in the production of electricity (European Parliament and the Council of the European Union, 2001). These international agreements form a very important part of the formal

institutional context, the role of which will be discussed in more detail in the second part of the analysis in chapter 5.

4.3 NEW PATH CREATION

The conceptual framework suggests that the phase of 'new path creation' is where new paths are formed (technological invention) and their proponents seek support from the formal institutional arrangements. Institutions are expected to respond and either put support in place or not. The new paths are seen as to some extent dependent on such institutional support for their development.

Whilst some important contributions to the knowledge base around wind energy technology were made by German scientists at German universities (e.g. Albert Beetz in Göttingen, Hermann Honnef in Berlin, Ulrich Hütter in Stuttgart), what is now considered the most efficient way of harvesting energy from wind, the three bladed model, was developed in Denmark and is thus commonly referred to as the 'Danish model' (European Wind Energy Association, 2009; Oelker, 2005). The inventors often were individuals, tinkerers in their own garages, yet well linked into a network of researchers as part of the Danish folk high schools and the above mentioned environmental movement. By the late 1980s they had built a respectable small wind industry, thus creating a new 'wind' pathway, whereas their German counterparts began to coordinate their efforts slightly later.

Many governments, including those of Britain and Germany, invested in explorative research on large scale turbines following the oil crises of the mid and late 1970s, thus keeping the support of the formal institutional environment within a particular scientific and cognitive paradigm. In Germany wind pioneer Ulrich Hütter suggested a smaller design, but the construction companies, supported by the research ministry, pressed ahead with the plan to create a very large machine at a diameter of 100m and output of 3MW, the "GroWiAn" (Große Windkraftanlage). The declared aim of the project was to seek a breakthrough in technology by sheer increase in size. The GroWiAn project was a financial disaster and a very public technical failure for the proponents of wind power in Germany (Gipe, 1995; Musgrove, 2010; Eisenbeiß, 2014). A lot of valuable knowledge was created through these efforts, however, and many involved engineers remained in the wind industry (interviewee G9).

[GROWIAN] was a disaster because they thought 'Oh that's low tech, let's build a 3MW one with 2 blades'. And that was a delusion. Actual development then started at 200 kW or somewhere around that. And it took 35 years until we have today reached 3MW as standard machines.

(interviewee G12)

I don't think that you can bridge technology through a political decision. You can speed up technological development by creating political and economic surrounding conditions which create a market and promise applications. But to promise something, when nobody believes it could work and where there is no market or network structure and no operating structures, that was three steps ahead.

(interviewee G13)

Most large scale projects of the time failed apart from one notable exception, a cooperatively built MW turbine in the village of Tvind in Denmark. A group of teachers decided to demonstrate the potential of wind turbines for electricity generation by building one of their own using second-hand materials and largely learning on the job. Apart from a minor blade failure, the turbine never experienced any noteworthy problems since its completion in 1975 and is still in operation today (Musgrove, 2010).

Whilst the Germans were starting out with this large industrial experiment, the GROWIAN, at the same time the Danes […] built the Tvind wind turbine at 1MW, there was no model beforehand, nothing. […A]t the same time when in Germany they said that this could never work, a group of volunteers and students showed that it could work.

(interviewee G10)

The vast shallow waters around its coastal areas make the UK the country in Europe with the highest offshore (and onshore) wind energy potential. The eventual recognition of this fact in the late 1970s led to three strands of wind energy funding activity by the Department of Energy. One was the formation of a consortium of construction companies, the Wind Energy Group (WEG). One was a piece of desk research which concluded in principle that wind energy was feasible but provided rather high cost estimates which dampened further interest. And the final strand was the promotion of research and development of vertical-axis wind turbines, for which a further consortium, Vertical Axis Wind Turbines Ltd, was formed. Following technical problems it was decided that the company should refocus its efforts in the development sector from 1989, changing its name to RES Ltd, which remains one of the largest global developers today (Musgrove 2010; interviewee B10). Building on a deliberate effort by government to encourage research and development in wind technology, the talented engineers of Wind Energy

Group can still be understood as path creators in Britain as they went on to develop a number of technologically advanced wind turbines that were competitive with the Danish and German products of their time. A number of interviewees did, however, also indicate a lack of commercial acumen.

We used to call it […] The University of WEG. It was a fantastic place to be, we were allowed to do all sorts of exciting things […]. And we developed all sorts of mathematical models and made all sorts of measurements […] and we made huge scientific steps, I would say. But really […] there was nobody interested in making it work commercially. So as soon as we got the MS-2 going there was a question of 'ok, what shall we do next' rather than 'how shall we sell this'.

(interviewee B5)

At this point the technological development in the three countries was at a similar stage, but whilst the wind sector in Denmark developed almost exclusively from the bottom up, in Britain it was dominated by large construction companies with government grants compared to a wide range of agents funded both by government and independently in Germany. Where there were independent engineers in Britain, they were doing their research in the realm of academia in protected, niche-like conditions as long as government grants were available. Where independent engineers in Germany failed to get governmental support they could fall back on financial aid from enthusiastic investors or local/regional banks supporting local projects.

4.4 PATH DEVELOPMENT

The conceptual framework suggests that in the 'path development phase' the institutional arrangements will co-evolve or not and new technological pathways will thus either strengthen with institutional support or perish without. An industry may be established out of market niches created by supportive institutions.

Constituting such a supportive formal institutional environment was an important early (from 1989) support scheme in Germany – '100 MW Wind'. Due to overwhelming demand it was enlarged in 1991 ('250 MW Wind'), but the subsidy was reduced. This encouraged the creation of the first wind farms in Germany, which were often co-funded by the Länder. These experiments led to a significant increase in newly built wind turbine capacity and helped build the basis of the German manufacturing market. A number of private individuals purchased smaller Danish and Dutch manufacturers of turbines and a number of domestic manufacturers of small turbines also emerged (Enercon, Tacke). The

northern Länder of Schleswig-Holstein and Niedersachsen launched their own significant wind programs in the early 1990s. They each committed to building 1000 MW capacity by the early 2000s (Szarka & Blühdorn, 2006; Lauber, 2012; Eisenbeiß, 2012; Ohlhorst, 2008).

Following on from and in parallel to those schemes on the national and regional level a law was put in place in 1990, the Stromeinspeisungsgesetz, which determined that renewable energy generators were to get guaranteed access to the grid and were to be paid for the electricity they produced (Deutscher Bundestag, 1990). Interviewees referred to the introduction of this law as the key institutional change for the German wind energy industry. In fact, a small number of producers were able to profit from both the previous wind programme and the new mechanism and regional subsidies on top of that, creating a short period of rapid wind deployment in the Northern Länder of Germany (Ohlhorst, 2008). Gipe (1995) emphasises that many of the German central government support subsidies went directly to small German firms with the subsidy reaching the end user, the farmer or the landowner who bought wind turbines, rather than larger producers.

In contrast in Britain to make it possible to privatise the nuclear industry it needed financial support. A mechanism, the Non-Fossil-Fuel-Obligation (NFFO) was introduced via the Energy Act 1989. It defined the obligation for suppliers to carry a certain share of electricity which wasn't sourced from coal and had a small tranche (about 1%) allocated to renewable energy (Musgrove, 2010). This led to a small number of successfully built wind energy schemes, but at this point the consortia of construction companies had already re-orientated towards more immediately profitable activities and the support mechanism was not large or reliable enough to tempt them back. New entrants were not encouraged either and therefore Britain's electricity industry was allowed to continue to evolve in a largely contingent way.

The mechanism itself had several flaws but interviewees particularly pointed out its irregular rounds of auctions and, because of the competitive nature of the mechanism, necessity to build at the best wind sites. This led to proposals in some highly sensitive areas and raised strong opposition from parts of the population who began to organise in citizens' groups. It must be mentioned, however, that NFFO did get a small number of projects delivered and was, in principle, open to agents of all sizes.

The entry and exit of individual companies is used for this study as a way of illustrating the development of the wind energy industry in Britain and Germany. Figure 4 on page 132 is a timeline showing entry and exit points of British (patterned) and German

(solid) turbine manufacturers. The list is not exhaustive but still provides a very good insight in the evolution of the sector. Whilst the very beginnings of the commercial wind industry and technology can be traced back to Denmark, British and German manufacturers were competing in the earliest period. The German sector has kept a broad variety of different manufacturers over time. What the figure illustrates well, however, is the lack of British turbine manufacturers beyond 1990. All three companies in Britain were consortia of large construction companies. Wind Energy Group, in existence as a company until 1997, had refocused its activities on project development in the 1990s. Vertical Axis Wind Turbine Ltd became RES Ltd, a global developer, after 1989. Howden's was an established manufacturer of heavy machinery and pulled out of wind in 1989, having been hit by costly failures and following a change in management. The Wind Energy Group's expertise lived on in other companies. The blade manufacturing site on the Isle of Wight was sold, together with the engineers and their knowledge, to NEG Micon, which was later taken over by Vestas. Many of the engineers from the Wind Energy Group found themselves working for Garrad Hassan established by former WEG engineer Andrew Garrad.

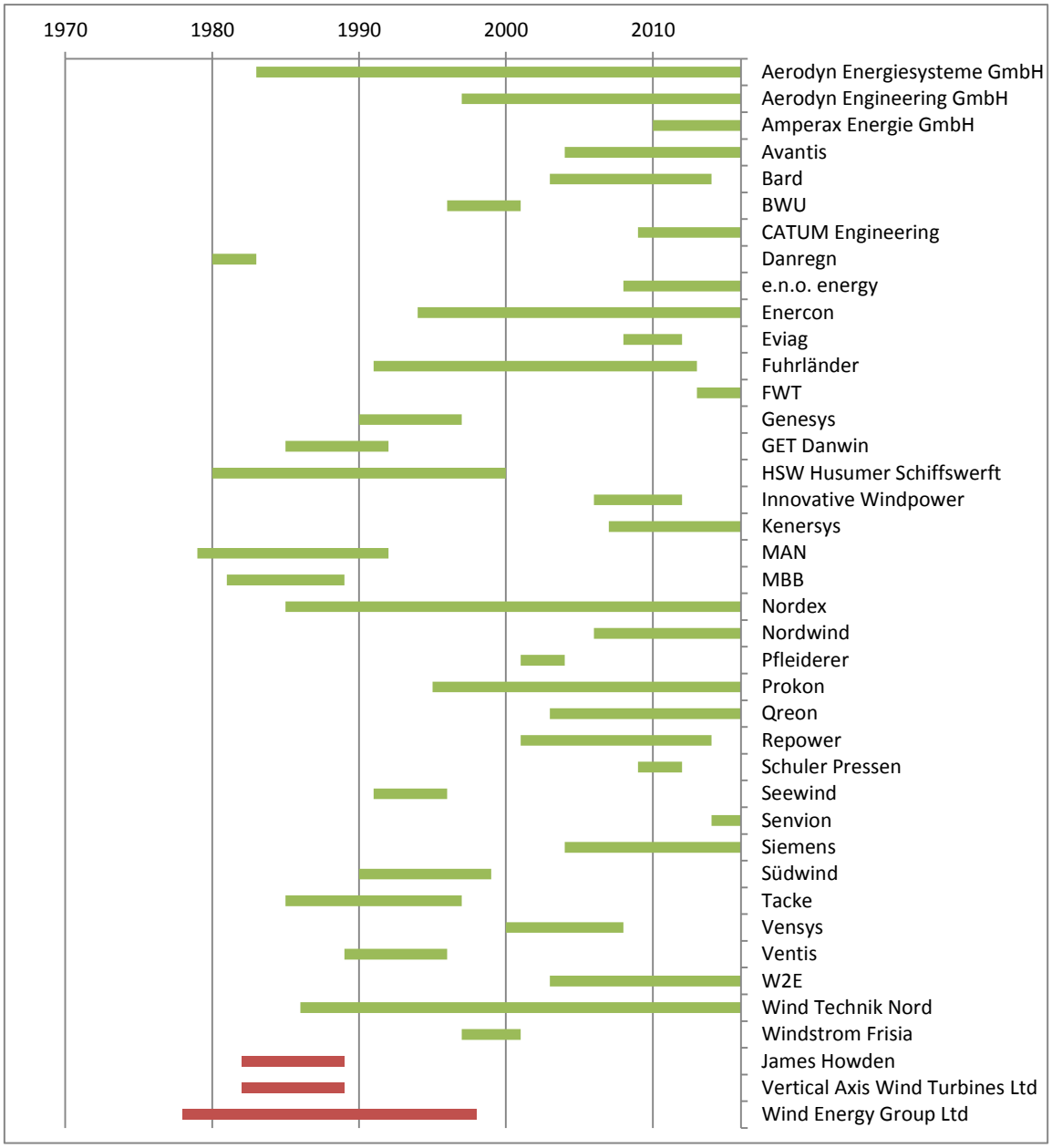


Figure 4: Time series of wind turbine manufacturers (Pierrot, 2016, adjusted by author)

4.5 PATH CONSOLIDATION

The fourth phase of the framework, 'path consolidation' describes a period where technological pathways are consolidated and industries expand, thereby changing the economic landscape because new technological pathways join or substitute existing technologies. The conceptual framework suggests that continued institutional co-evolution is a necessary condition. If the institutions continue to be unsupportive, then no new pathways can be established, the economic landscape is in danger of getting locked in to one technological pathway and institutional hysteresis continues.

From 1995 the subsidies on the regional level were reduced. Cost reductions in production did compensate for this. Myriad factors led to reduced demand for turbines in the German market for a short period causing a first consolidation of parts of the German wind turbine industry. Increased exports could somewhat soften this blow to the industry. In light of European Union market rules, which demanded the unbundling of vertically integrated electricity companies, access for independent producers of energy including wind energy producers was secured in 1998 through an obligation on the grid owners in Germany. As part of the market liberalisation of the energy market, the Verbundunternehmen were significantly reduced and only four large firms (RWE, EnBW, Vattenfall and E.ON) survived, besides a large number of small, local firms (Ohlhorst, 2008).

Ohlhorst (2008) diagnoses a wind energy boom phase from 1998 followed by further consolidation between 2002 and 2008. Wind energy experienced a boom because of the increased pressure from superordinate institutions and international agreements as well as, internally in Germany, the liberalisation of the energy market. Nationally the change of government to a 'red-green' coalition (SPD – Green) under Chancellor Gerhard Schröder brought a positive shift of attitudes towards environmental politics from 'the top'. The consolidation of the industry materialised in the mergers and take-overs of a number of established companies in the European turbine market. Large, internationally governed companies diversified into wind energy. Much of this was done by buying struggling existing wind turbine producers. The best known multi-national to enter the industry at this stage was Siemens, who bought the Danish wind turbine producer AN Bonus in 2004 together with its offshore expertise and subsequently became the world leader in offshore wind energy technology. Tacke Windtechnik GmbH, formerly the second largest German wind turbine producer became insolvent in 1997 and was acquired by the US electricity company Enron. Following the insolvency of Enron General Electric took over the wind turbine production business in 2002 and has company headquarters for its wind section in Lower Saxony. Vestas also merged with the well-established Danish producer NEG Micon in 2004 to become the largest wind turbine producer in the world [2013]. Enercon continued to establish a dominance in the German onshore industry and also increasingly on the global onshore market. Enercon remains focused on onshore with no intention to expand into offshore operations. The direct drive technology initially developed by Aloys Wobben has set standards in the industry and Enercon upholds its grip on this section of

the turbine market (Bundesverband Windenergie, 2015b). These are some of the most prominent examples of the wider trend of an industry consolidation in this period.

In 2000 the German government decided on exit from nuclear energy by 2022. To reach Germany's ambitious GHG emissions reduction target (25% of 1990 levels by 2005) it became clear that the feed-in law for renewable energy needed a fundamental overhaul (Ohlhorst, 2008). In early 2000 the Erneuerbare Energien Gesetz (renewable energy law) was agreed upon, which not only guaranteed that independent producers could feed in their electricity but also gave electricity from renewable sources preference. It defined fixed tariffs for a period of 20 years (with a reduction over time) and a duty on the network operator to expand the network if this was necessary for the connection of new schemes (Deutscher Bundestag, 2000). A change of government in 2005 meant that the German government started wavering on its commitment to an end to nuclear power generation. In 2010 chancellor Merkel announced a delay of the nuclear phase-out to 2030 (Taylor, 2016). Citizens responded by attending demonstrations against this in great numbers. Following the contingent events of an earthquake and Tsunami in Japan and as a consequence a serious incident at Fukushima nuclear plant in 2011 Chancellor Merkel decided to follow through with a complete exit from nuclear. The Chancellor seems to have been well aware of the popular sentiment and potential repercussions as, although she claimed to have made a deeply personal and emotional decision, most observers assess that political calculation was involved. Her party was facing a number of by-elections the same year (Taylor, 2016). This was the beginning of 'Energiewende' as a policy slogan, cementing the end of nuclear power into German energy policy. Since then no party has been supporting nuclear power openly in Germany.

In the UK the formal institutional arrangements were changed in 2002 when a new mechanism, the Renewables Obligation (RO) put the obligation on existing energy companies to produce a certain percentage of the electricity they provide from renewable sources. It may be argued that there was institutional co-evolution in that the formal institutional arrangements were amended and the RO introduced. This happened mainly in response to increasing international pressure, but also because the incoming Labour government of 1997 was looking for political fields to occupy. The original RO system was technology-neutral, meaning that it was not prescribing the energy source used and left the price-setting to the created market. Despite its complexity and many weaknesses the RO changed the domestic market drastically (Musgrove 2010). The Energy White Paper of 2007 introduced technological differentiation, which resulted in an amendment of the

mechanism in 2008 encouraging extended use of biomass and offshore wind deployment. Support for onshore wind remained the same (Department of Trade and Industry, 2007). The RO did trigger considerable wind energy deployment, particularly offshore, but this was mainly driven by relatively large companies as the mechanism did not encourage new entrants. Due to pressure by groups like the Renewable Energy Association (REA) a feed-in tariff system was introduced in 2010 in order to support smaller energy producers as well (HM Government, 2008).

4.6 LANDSCAPE CHANGE

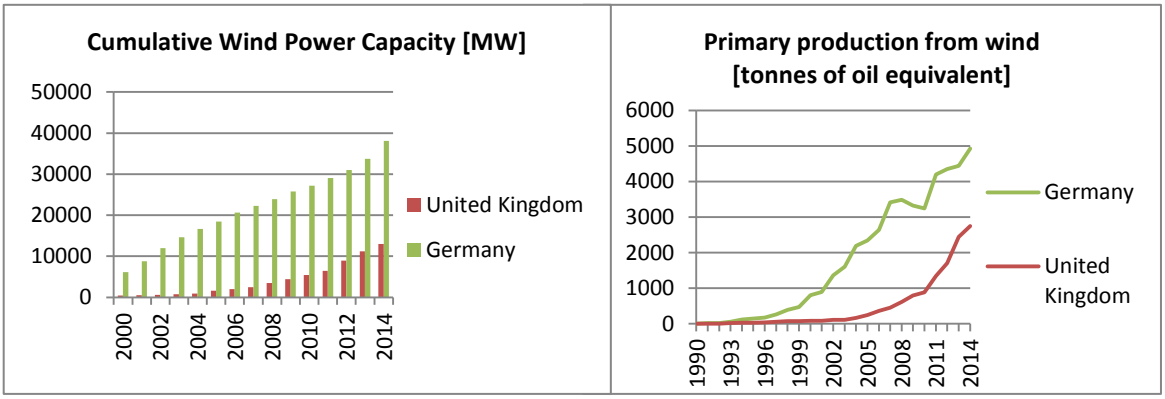


Figure 5: Cumulative wind power capacity [MW] (Deutsche Windguard GmbH, 2015; DECC, 2015, adjusted by author)

Figure 6: Primary production from wind [tonnes of oil equivalent] (eurostat, 2016h)

Figure 5 shows the cumulative installed capacity, indicating the diffusion of the technology in both countries between 2003 and 2014. This illustrates the pre-existence of a strong home market in Germany while deployment of wind power in Britain has only just been starting to grow significantly in the early 2000s. Figure 6: Primary production from wind [tonnes of oil equivalent] (eurostat, 2016h) shows the levels of primary wind power production. It shows that while wind power in Germany had started to gain significance in the early 1990s it took a good ten more years for the United Kingdom to reach similar levels of production. The effect of the formal institutional arrangements in the form of the Renewables Obligation in the UK is apparent and also the redirection of funds towards offshore wind and the introduction of a feed-in tariff from around 2010. In contrast in Germany amendments to the policy framework from around 2004 resulted in a flattening of the growth curve and even a sinking tendency between 2007 and 2010. This may also be because of the first generation of wind turbines running out of service around that time.

It is apparent that in recent years the dynamics of the energy systems have shifted in both countries. Whilst Britain celebrates successes in 'decarbonising' the energy system (PricewaterhouseCoopers LLP, 2014) and its deployment of large scale offshore wind farms the German government too seems to begin to favour larger, corporate agents over small individual ones. This is evident in its transition towards a competitive tendering system, away from fixed tariffs defined by the policymaker. Despite the fact that this has been strongly encouraged by the European Commission, it is a cause of great concern to representatives of community energy initiatives in particular but also for a lot of the original agents that drove 'Energiewende'.

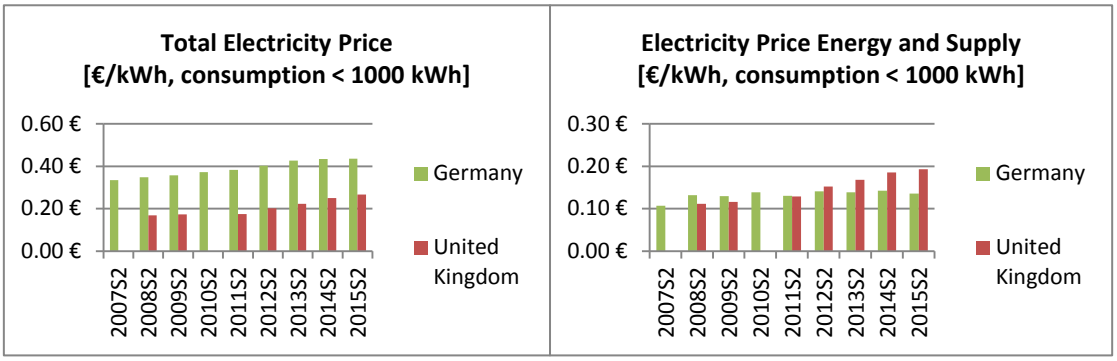


Figure 7: Total electricity price and energy and supply price [€/kWh, consumption < 1000 kWh] (eurostat, 2016a)

Figure 7 compares the prices for electricity between Germany and the United Kingdom. The left graph compares the total electricity price in the United Kingdom and Germany. It shows that German customers pay about a third more for their electricity per kWh. This is often used as an argument against renewable energy both in Germany as well as in other countries. The basic price for electricity, however, appears to have been rising since 2008 in Britain whilst the basic price for electricity in Germany appears to have reached a plateau and now has a sinking tendency. Dillig et al. (2015) present a counterfactual and compare the present situation with a scenario situation without renewable sources of energy, wind and solar in particular, filling gaps that arise from the upcoming end of life span of existing plants. Renewable sources are thus understood as fundamental to secure supply. They argue that renewables did not actually push the price of electricity in Germany up but brought it down instead.

The two figures below represent the total electricity prices and show the shares of the basic price, the network costs, and the taxes and levies. They make clear that, against popular belief and indeed political rhetoric, taxes and levies make up only a small part of

the total electricity price in the United Kingdom (less than 10%), whereas they represent a good third of the electricity price in Germany.

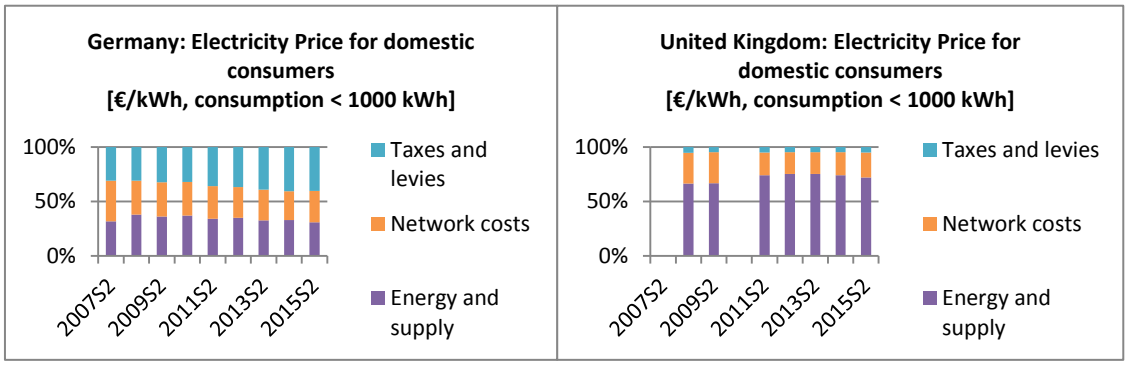


Figure 8: Electricity price for domestic consumers [€/kWh, consumption < 1000 kWh, Germany and United Kingdom] (eurostat, 2016a)

At this point it is interesting to take a look at the preparedness to pay more tax in the two countries. Two surveys, one from 1990 and one from 1999, do show a higher preparedness to pay increased taxes if the extra money was dedicated to the environment in Britain. In 1990 a considerable 70% of respondents strongly agreed or agreed to such increased taxes and in 1999 this figure was still at 50%. This allows the suggestion that the United Kingdom would actually have a certain leeway in terms of people's preparedness to accept higher taxes if these were dedicated to the environment but has not been making use of this.

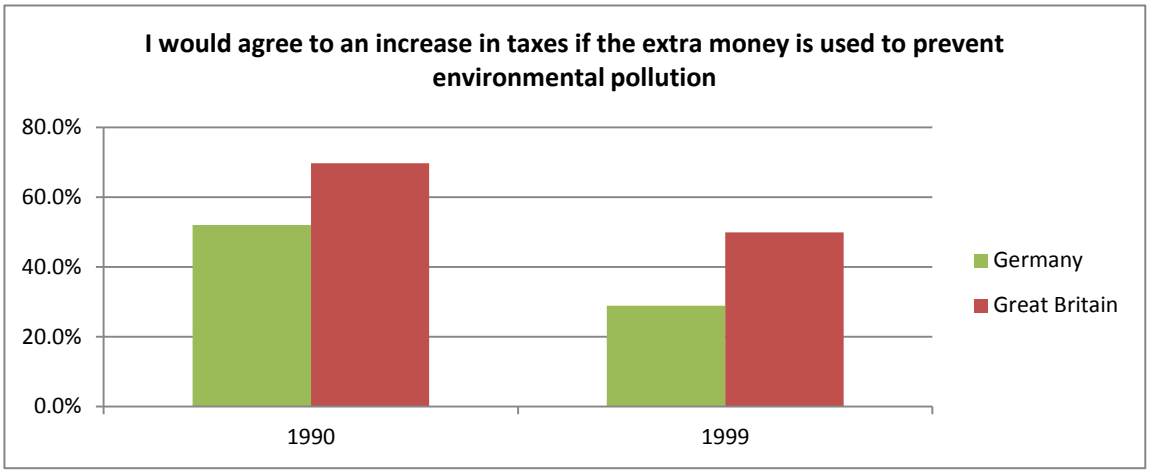
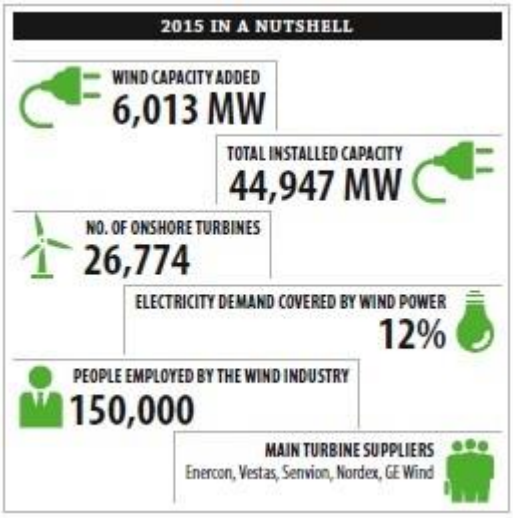
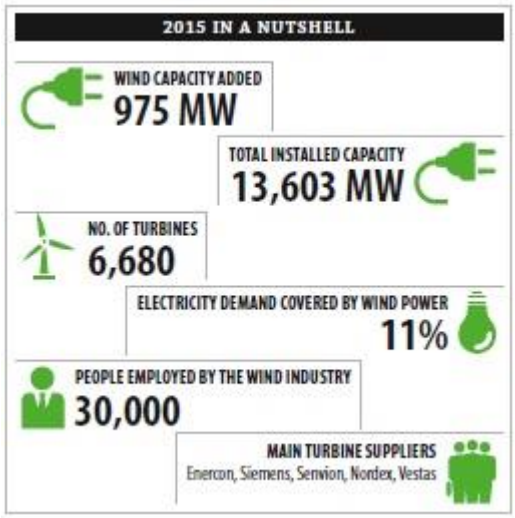


Figure 9: Agreement to an increase in taxes if the money is dedicated to the prevention of environmental pollution [1990, 1999; strongly agree + agree] (EVS, 2015)

4.7 KEY DIFFERENCES BETWEEN THE GERMAN AND THE BRITISH WIND ENERGY INDUSTRY

GERMANY





BRITAIN

Figure 10: Wind energy in Germany/United Kingdom in 2015 in a nutshell (Global Wind Energy Council, 2015)

The two boxes in Figure 10 illustrate the current situation of the wind energy industry in each country (Germany on the left, Britain on the right). For many people a key 'problem' of wind energy is the visual impact of the turbines on the landscape. It is fair to point to the total number of turbines in both countries where Germany has more than 26,000 turbines onshore alone whereas Britain only has 6,680 turbines, most of which 'out of sight' offshore and apparently achieving similar outcomes in terms of the share of electricity demand. What is clear is that, in terms of an energy transition, Britain has seen remarkable development recently, catching up mainly through offshore wind development, covering a total of 17.8% of electricity demand by renewable energy in comparison to a total of 28.2% in Germany [2014] (eurostat, 2016d). The author, however, would like to direct the reader's attention to the main turbine suppliers and the numbers of people employed by the wind industry. Apart from one each the same 3 German and 1 Danish companies supply the turbines in both countries and there are five times as many people employed in the wind energy industry in Germany as in the United Kingdom. Sadly, despite the existence of producers at the forefront of technology at one point, so a similar starting point, Britain did not succeed in reaping the socio-economic benefits of what has become a global development in the same way that Germany has.

The two case countries started from roughly similar positions in the early 1980s in terms of technological development and the beginnings of industrial development. Significant contingent events, like those of nuclear incidents at Chernobyl in 1986 or Fukushima in 2011, as well as the creation of new technological pathways affected the countries' techno-industrial development in different ways because of key differences in the institutional constellation, which will be discussed in the next chapter.

Whilst this chapter has provided a summary of the development of the wind energy industry in Germany and Britain from a path dependency perspective, the aim of this study is to explain the above-mentioned differences. The path dependency perspective is not sufficient to analyse such a divergence in development as it does not account for different institutional constellations. The contribution of this study is a more detailed analysis of the institutional dynamics which influenced this divergence in development. It will be shown that the institutional constellation had a crucial impact on agents' perception of and capacity to act upon technological change and changing circumstances. Different types of institutions played a stronger or weaker role over time in each case country. The main difference was between the role of informal and formal institutions. Where the latter allowed for the former to provide access channels to the formal institutional arrangements, institutional co-evolution was possible, disruption by new entrants was enabled, and new pathways were introduced and eventually reached maturity. Where the formal institutions were too rigid to provide such access channels, the energy system continued to develop in a path-dependent way, determined by contingent events and self-reinforcing mechanisms, with little challenge to the existing power structure. Where new pathways had been introduced, they were not developed further within the country or failed altogether because of the lack of support.

This will be analysed and shown in detail in the following chapter through the lens of the analysis framework introduced at the end of the literature review.

5 Analysis II: The Role of Institutions for the Divergent Development

5.1 INTRODUCTION

Whilst the previous chapter presented the history of the development of the wind energy industry in descriptive terms from a path dependency perspective, the following chapter will focus on the inter-relationships between the three kinds of institutions defined by North (1996; 1991). This will highlight the specific role that both formal institutional arrangements and informal institutions play in industrial development.

The key proposition to this study is that the economic landscape evolves in a path-dependent way, but that institutional constellations in different countries filter how agents perceive and act on technological development or changing circumstances. The analysis framework suggests that informal institutions are important to the formation of new industries because they impact on the co-evolution of the formal institutional arrangements with technological development and in response to changing circumstances. Informal institutions influence the behaviours of agents across society and thereby may provide access channels for new ideas leading to change of the formal institutional arrangements. In the absence of such channels institutional hysteresis may continue as well as the path-dependent evolution of the economic landscape.

The following first section reiterates the analysis framework and explains the key institutional elements. The rest of the chapter is structured around these elements. First, the role, origin and inter-relationships of the most important institutions for the case of the wind energy industry are introduced. It is then shown how agents are constrained by institutions but also have capacity to evaluate them. The next section argues that the development paths between the two case countries diverged and an explanation of why this was the case for each country follows. It is argued that the relatively open formal institutional arrangements in Germany provided access channels for new ideas originating in the informal institutional realm. This led to institutional co-evolution and helped the wind energy industry in its development. In contrast the relatively closed formal institutional arrangements in Britain allowed elite capture and prevented new ideas from getting a foothold which meant that institutional hysteresis continued and prevented the wind turbine industry from blossoming.

A final section summarises why the industrial development of the wind energy industry in Germany and Britain diverged and comments on the socio-economic outcomes of this.

5.2 THE ANALYSIS FRAMEWORK

In order to enable the analysis of the inter-relationships between institutions that are argued to influence the formation and success or failure of new technological pathways an analysis framework was created.

The key argument is that informal institutions, through their impact on the behaviour of agents, critically influence the degree to which the formal institutional arrangements co-evolve with technological development or changing circumstances. At the same time the degree of openness of the formal arrangements conditions the ability of agents to instigate institutional co-evolution.

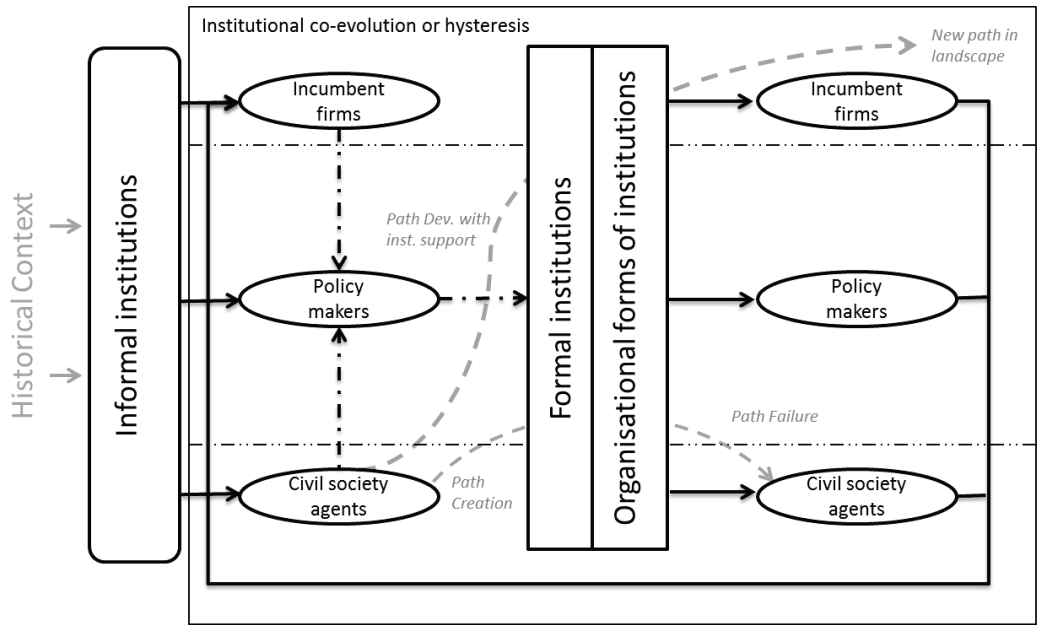


Illustration 9: Analysis Framework

The analysis framework provides further detail on the role of institutions for the path dependent development of the economic landscape, which was proposed in the conceptual framework. Whilst the latter only indicates that there are important inter-relationships between institutions, the analysis framework proposes concrete dynamics. The multilevel structure remains in place as do the pathways. Transitional innovation is understood to originate amongst the civil society by individual inventors, supported by innovators and taken up by citizens, or in a collective effort amongst social movements. These new pathways are then filtered through institutional constellations and need to gain the support of a broad range of agents. If they succeed, then the pathways will develop and

join or substitute existing pathways in the landscape. If they do not succeed, then they will fail.

At the core of the analysis framework is the ongoing dynamic of evaluation and reproduction between agents and institutions. Agents meet the pre-existing institutional arrangements (formal institutions and organisational forms of institutions) and are both constrained and enabled by them. They do, however, have some capacity to evaluate and amend them in light of technological innovation or changing circumstances. If they act on this capacity, then institutional co-evolution occurs. If they fail to do so, institutional hysteresis may continue. The thus maintained or amended institutional arrangements will constrain and/or enable agents henceforth. This process is critically shaped by informal institutions as they impact on agents' willingness either to accept the existing arrangements or to make amendments. Thus informal institutions can provide access channels for new ideas leading to formal institutional change. At the same time the pre-existing formal institutional arrangements may be so rigid that they prevent such access channels and agents are likely to accept and perpetuate a status quo. The degree of their capacity to change and amend (i.e. co-evolve) institutions depends on the malleability of the formal institutional arrangements which is largely determined by history. The informal institutions themselves are influenced by a number of contextual factors, including the pre-existing formal institutional arrangements. The study argues that both formal and informal institutions have a crucial influence on where, when and how industrial development occurs and therefore economic geography should consider both explicitly, taking the concept of informal institutions beyond that of social capital.

The following section will trace the key dynamics described in the analysis framework and provide evidence for their presence in the case of the wind energy industry in Britain and Germany.

5.3 KEY INSTITUTIONS – ORIGIN AND INTERACTIONS

5.3.1 Formal Institutional Arrangements

The study argues for the significant role of institutions in understanding industrial development across countries and regions. Whilst the economic landscape is seen as path-dependent, institutions are argued to have a crucial filtering impact on how technological development or changing circumstances are perceived and acted upon by agents. They need to co-evolve with such technological development and changing circumstances in order not to hinder new path creation and path development.

Both formal institutions as well as organisational forms of institutions are seen as constitutive of the formal institutional arrangements. It is important to consider the rigidity or openness of the formal institutional environment because of its role for allowing access channels for new ideas. In the present case of the wind energy industry in Germany and Britain it appears that more rigid, closed formal institutional arrangements in Britain prevented new ideas from getting a foothold with policymakers in the way that they did in Germany.

The key formal institution for the present case is the energy law in both countries as is evident from Figure 11 on page 146. This was the most talked about formal institution. As explained in section 3.5.2 in chapter 3 this means that this formal institution was found to be treated in the greatest share of text on average across interviewees. From the figure it is apparent that rules on finance and borrowing policies was a close second in Britain, whereas there is a much greater gap for Germany. The explanation for this is that for Britain interviewees often mentioned the lack of finance as a key problem for the industry, whereas this was a problem that was not seen as equally pressing in relation to Germany. Rules on planning and finance feature to a similar extent in conversations about Germany and a closer look at relevant interview parts revealed that planning has mostly been described to play a strong enabling role in Germany whereas it was depicted as more of a hindrance for British agents.

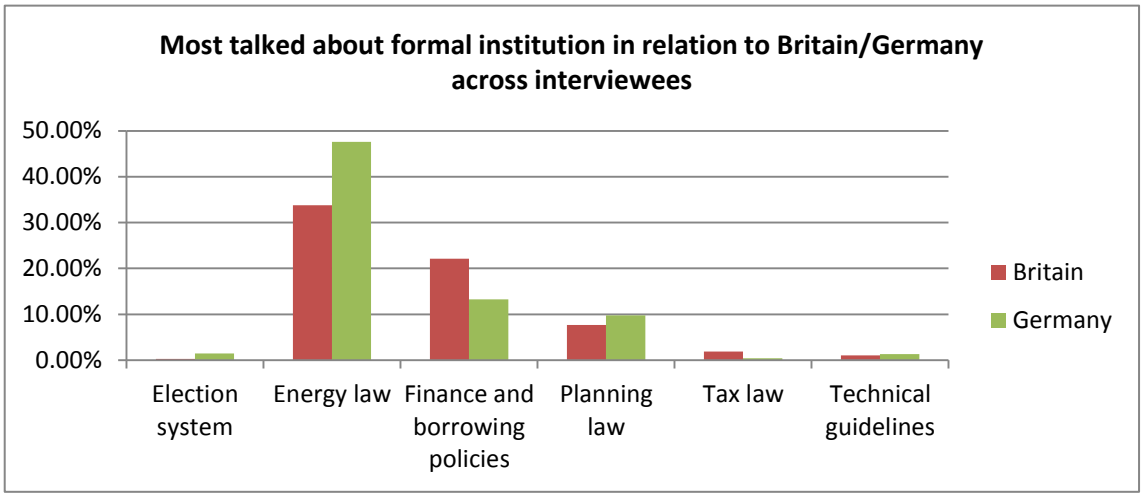


Figure 11: Most talked about formal institution in relation to Britain/Germany across interviewees, own analysis

One important part of the formal institutional arrangements in the initial period of exploration in wind energy is the significant regulatory barriers that were in place and persisted for a long period in Britain. One such barrier is that, before the Energy Act was passed in 1983, individuals had no right to connect wind turbines to the national grid. A second one was the significant property taxes that anyone that owned a wind turbine site in the UK would be required to pay. These were set at such a high rate that any income from the electricity generation would be used to pay for them and then would still leave the cost of maintenance and operation to account for. As a consequence there was no market for independent electricity generation from wind turbines in the UK for most of the 1980s. The large electricity utilities enjoyed special, lower rates. This was only adjusted in 1990 when it was decided that all generators had to pay rates determined by the maximum power output. For wind turbine sites that meant that rates were then similar to the rates that were previously only enjoyed by the large utilities (Musgrove 2010).

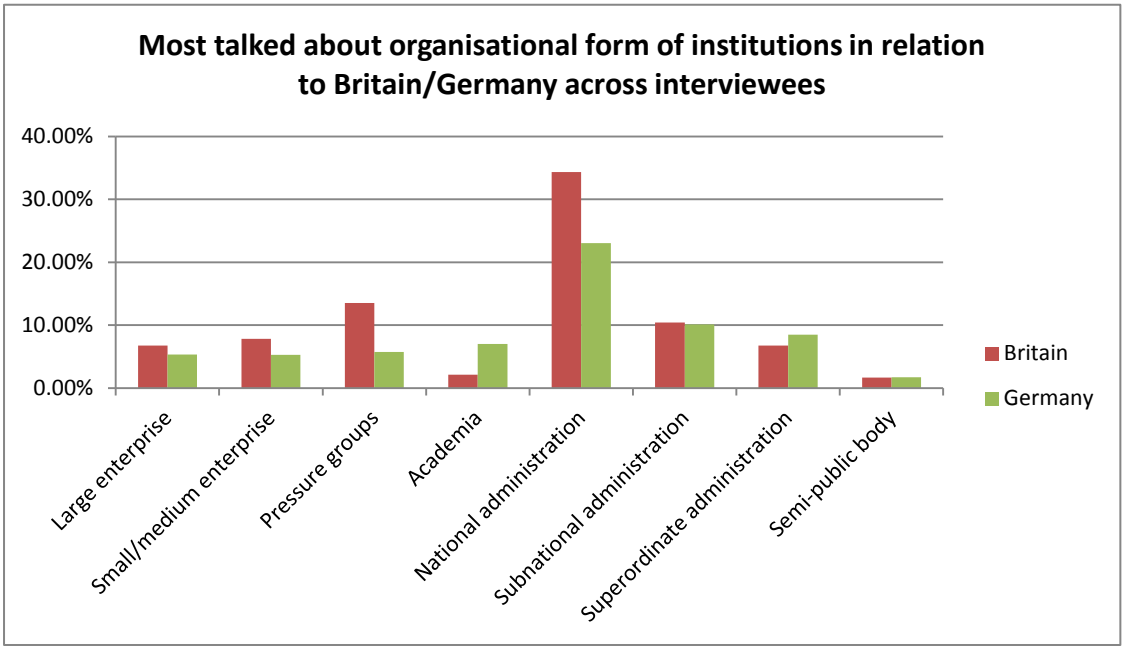


Figure 12: Most talked about organisational form of institutions in relation to Britain/Germany across interviewees, own analysis

In terms of organisational forms of institutions (Figure 12) the national administration was most talked about for both countries but relatively more for Germany. This allows the inference that the most influential organisational institution for the development of the wind energy industry in Germany was the administration on the national level, which was also confirmed by individual interviewees in the pilot phase, which reinforced the choice to keep the comparative study mainly between the two nations. A key role in Germany is with parliament, where the decision to put supportive measures for renewable energy in place was not made solely by government but grew out of cross-party consensus. Once the general direction towards a greener energy system was clear, a great deal of investment was channelled into providing (formal institutional) support for this new industry. This formed the environment for the industry to flourish. Skilled labour became available and popular support kept increasing. This was not only but also due to the increasing knowledge base created by research directly funded by the government. The German ministry for the environment needs to be mentioned here as extremely influential. It took energy matters in its portfolio, following increasing Green party power and demands. The responsibility has since moved back to the ministry for economy again, reflecting a rise in the perceived 'importance' of renewable energy but also in attitudes towards Energiewende which is recently increasingly understood to be a matter of economic rather than environmental policy. Interviewees suggested that the relatively

low attention that was given to renewable energy policy initially was an advantage as much of the work could be carried out by civil servants without needing approval from ministers (SoS equivalent).

Figure 12 above also contains the rates for firms, with large and small to medium enterprises illustrated separately. Overall they were talked about to a similar extent as subnational and superordinate administration and there is no significant difference in the rate between the two countries. Closer analysis of the interview data regarding firms, however, reveals considerable differences in the character of the firms involved in the wind industry in the two countries. Whilst the initial three wind turbine producing firms in Britain were large engineering companies or consortia of construction companies with their focus not primarily on wind energy their counterparts in Germany and Denmark tended to be small and medium enterprises with their main focus on the creation and development of wind energy technology.

No major corporations were behind this. These were passionate individuals, ingenious inventors, convinced engineers, who really thought that this development was right, given that we have only limited energy resources and need to go down this path.

(interviewee G11)

Some interviewees also indicated that expected rates of return played a considerable role for investors in Britain whereas they were less important for investors in Germany where finding and developing alternative sources of energy beyond nuclear and fossil fuels was the dominant motivation. This later influenced policymaking on a European level where it was claimed that single digit rates of return would not be attractive to industry and therefore British representatives tended to favour competitive instruments over consumer subsidies (interviewee G13, G16). This difference in the characteristic of firms in the early years of the industry in the two countries is strongly inter-related with other formal institutions like the sources of funding available to the fledgling industry. Whilst the early British wind energy industry was relying on manufacturing incentives for large scale efforts the nascent industry both in Germany and Denmark was growing based on a consumer subsidy which encouraged a very broad range of agents to get involved, a variety both in producers and developers which remains today (Cooke, 2011; Cooke, 2012b; Bundesverband Windenergie, 2015a). This consumer focused subsidy lent important security to the investors in Germany, especially from around 2000 when a guaranteed subsidy period of 20 years was introduced. German firms could rely on funding from a wider range of sources, both public and private, and on banks with a regional or local

development remit for favourable credit arrangements. British companies were not receiving equal support but were made to compete in the European market with companies that did receive significant backing by their governments – notably Danish and German manufacturers (interviewee B8). When public funding was withdrawn entirely in Britain firms either pulled out of wind energy, were bought out or changed their focus toward development of sites and consulting which fitted in better with the dominant government ideology around the envisaged role of manufacturing and services in Britain and was expected to yield greater returns on investment.

Another firm related aspect is the entirely different character of the offshore wind industry where large corporations were dominant right from the beginning in the early 2000s. This is mainly because of the greater dimensions, planning periods and investment volume required. Agents involved in the offshore industry were very well able to influence policymakers in its favour and secure significant governmental support in both countries. A multi-agency analysis of influential factors for the development of the offshore industry in the North East of England as well as Scotland can be found in Dawley (2013) and Dawley et al. (2015). Whilst the offshore industry path has been supported overall in Britain it is shown to be very sensitive to the regional policy environment.

Further strong differences between the two countries are seen in the role of academia as well as in the role of pressure groups. Whilst the former was talked about more in relation to Britain, the latter was talked about more in relation to Germany. The role of academia in the development of the wind energy industry in Britain was mainly that of providing a niche-like environment as long as the government funded this research. Even efforts at coordination spun out of university research in Britain and the British Wind Energy Association (now RenewableUK) has its origins in academic research (Musgrove, 2010). The greater perceived relevance of pressure groups in Germany may be seen in the context that inventors in Germany were rather disparate at first and only became more organised with the establishment of the German wind energy club, later renamed German Society for Wind Energy in the late 1970s, out of which eventually grew the German Wind Energy Association. Representative groups such as this one had a strong influence in the making of the most important change of energy law, the Renewable Energy Law of 2000 as will be illustrated in more detail below. Also regional fairs like that in Husum and test centres which received funding from local and regional government helped to coordinate efforts and build the network (Rave & Richter, 2008). These would appear as semi-public bodies in the figure above which, in the bigger picture, appear to have played only a small

role in either country. Yet, funding efforts like these of the subnational administration have contributed considerably to the initial boom of wind energy in the northern regions of Germany in the late 1980s and 1990s. Similarly the increasing pressure from superordinate administration like the European Union but also via international agreements would have played a significant role in a perceived need to adapt policy. The figure does not, however, indicate a greater role of it than of subnational administration and certainly not than of national administration.

5.3.2 Key Informal Institutions and Their Origin

This study argues for a greater consideration of the role of informal institutions for understanding industrial development. They are understood to be pervasive across society as attitudes and values affect the engagement with and investment in new technologies by the general public. They constitute the motivation for inventors, innovators, and entrepreneurs to act, for policymakers to amend or develop new policy, and even for incumbent firms to change their business practice in response to public pressure or internal changes. Thus informal institutions can provide important access channels for new ideas leading to the change of formal institutional arrangements. The rigidity of the formal institutional arrangements, however, also impacts on whether such access channels are allowed to form.

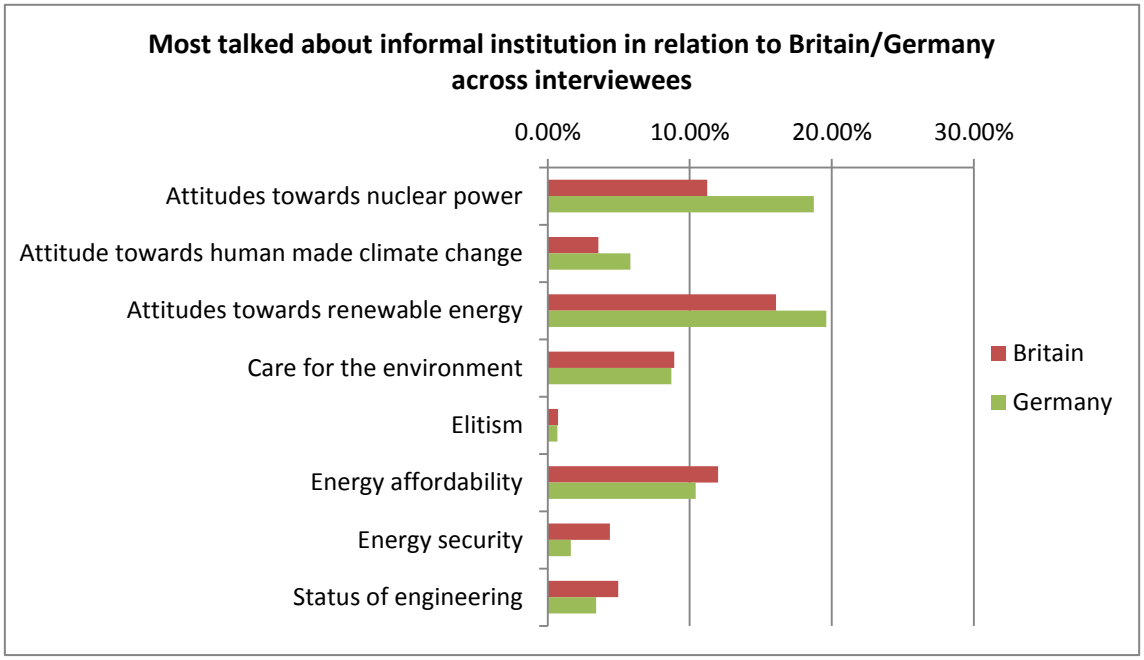


Figure 13: Most talked about informal institution in relation to Britain/Germany across interviewees, own analysis

Figure 13 on the previous page illustrates that, amongst all informal institutions coded for, the attitude towards nuclear power and that towards renewable energy were talked about most. The concern for the affordability of energy as well as a generalised concern for the environment was also frequently found. This allows the inference that the general attitudes towards nuclear power and renewable energy are seen as the most influential in relation to the wind energy industry development. Between Germany and Britain it is most obvious that the attitude towards nuclear power appears to have played a much stronger role in Germany, where this is the most talked about. A general attitude towards renewable energy seems to be more important for Britain but not more than for Germany.

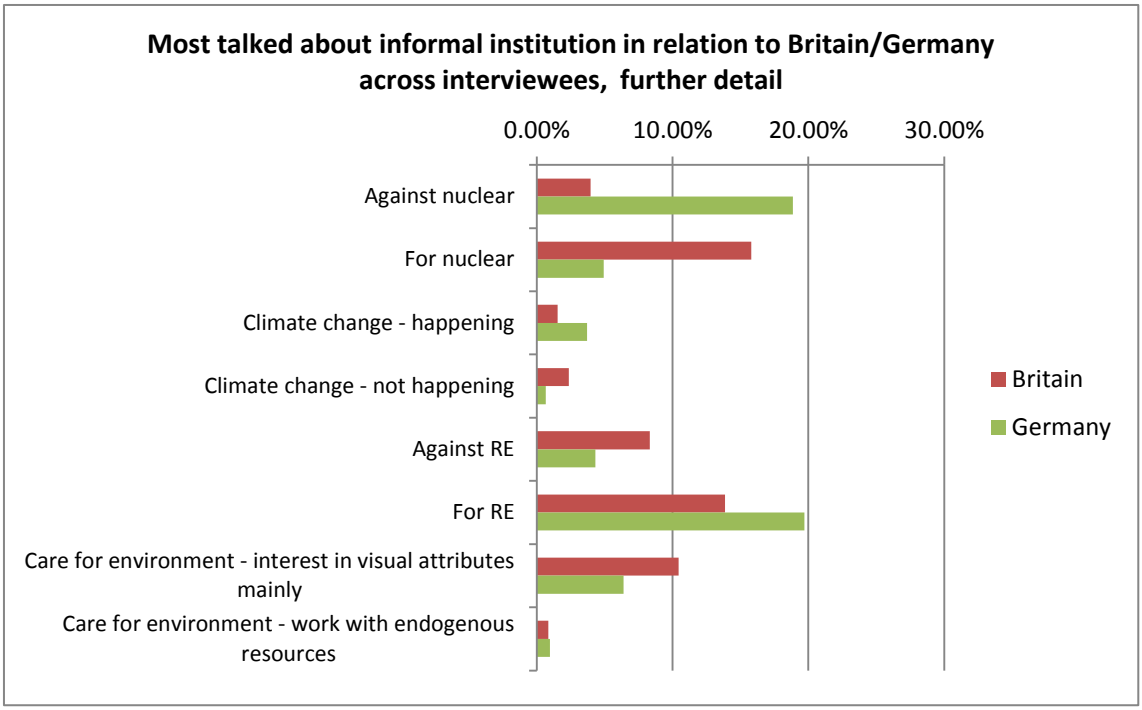


Figure 14: Most talked about informal institution in relation to Britain/Germany across interviewees, further detail, own analysis

A total of 25 out of 36 interviewees felt compelled to address negative attitudes towards nuclear energy when asked about the origins of the wind energy industry. 100% (18) of all German interviewees mentioned this. A more detailed look at some of the finer grained distinctions of informal institutions using the lower level in the coding frame (which can be found in Appendix 8.8) reveals interesting detail about these attitudes (see Figure 14). Generally there is an inverse relationship between Germany and Britain for positive vs negative attitudes towards nuclear power as well as for the acceptance or denial of human made climate change. For attitudes towards renewable energy the relationship is

the same. There is more coverage about positive attitudes towards renewable energy overall in relation to both countries. This is likely to be an effect of interviewee bias where most interviewees are highly likely to have a positive attitude towards renewable energy and would have expressed this. Participants were four times more likely to refer to negative attitudes towards nuclear energy in relation to Germany than to Britain. This is a strong indication that this attitude was very important for the development of the wind energy industry in Germany. Care for the environment with a focus on the preservation of visual attributes is also considerably more talked about for Britain than for Germany. This may be an indication of the greater local acceptancy problems that wind energy faces in Britain than in Germany.

	Anti-nuclear		Pro-Nuclear	
	BRITAIN	GERMANY	BRITAIN	GERMANY
1945 - 1980	0%	100%	24.54%	75.46%
1981 - 1990	18.92%	81.08%	68.81%	31.19%
1991 - 2000	0%	100%	69.21%	30.79%
2001 - 2010	18.92%	81.08%	0%	0%
2011 - now	39.76%	60.24%	86.37%	13.63%

Table 7: Spread of conversation about 'attitudes towards nuclear power' in Britain vs Germany [percentage coverage, by time period], own analysis

Table 7 shows the spread of the conversation in relation to each time period across Britain and Germany for negative and positive attitudes towards nuclear energy. The general trend is clearly towards a dominance of positive attitudes in Britain and towards negative attitudes in Germany, although there appears to be an overhang for Germany in the post-war years until 1980 (more detailed analysis showed that this is down to a longer text passage explaining about the top-down implementation of civil nuclear power into the German energy system in the 1960s).

The early 1980s saw the rise of a number of environmental and anti-nuclear movements in Europe and the US. These have been influential in shaping European energy politics. Both Sine and Lee (2009) and Vasi (2011) diagnose a pivotal role of social movements to galvanise civil society into action. Many wind pioneers state their involvement with the anti-nuclear or the environmental movement as their main motivation with potential profits being only secondary (Oelker, 2005). Beyond the mere engineering challenge finding a possible alternative for nuclear energy provided them with an emotional driver. Such a 'common goal' is identified as a key ingredient for inclusive

local and regional development by Essletzbichler (2012). "Inclusion and support is easier to obtain at the local level if people, businesses and policy makers can rally around common goals and engage in the design and implementation of local transition pathways that gel with local endowments and result in benefits for local communities through job creation and revenues from energy sales" (p. 83).

The widespread anti-nuclear attitudes also had a direct impact on the availability of funding, where many inventors in Germany funded their initial research via grants and loans from friends and relatives who shared their idealistic vision of alternative sources of energy or were fed up with the practices of the oligopolistic energy companies. Many citizens decided to invest in renewable energy on this basis.

This creates momentum. I know a lot of people, who, with this attitude invested in wind power, independent of whether they are going to become rich or not.

(interviewee G15)

Several high profile accidents at nuclear power stations, notably those at Three Mile Island in the US in 1979 and Chernobyl, Ukraine in 1986 have also strengthened the anti-nuclear sentiment in Germany (Kriener, 2016). Somewhat strangely they seemed to have affected public perception less in Britain, but this is also true for the events of Fukushima in 2010 (de Boer & Catsburg, 1988; Poortinga et al., 2014). Poortinga et al. (2014) point out the relative resilience of British attitudes and suggest a possible reason is the quality of reporting and thus the framing of the problem in the media. Childs (2001) asserts a concentration of ownership and an increasing over-representation of right-wing views in the media resulting in strong association of the Conservatives with the press which has lasted until the mid-1990s, when Tony Blair introduced his Labour party to a new, closer relationship with the press himself. Although support for renewables is strong in both countries it is clear that the British population have accepted nuclear power as a definite future source of 'low carbon' energy whereas the German population are much more hesitant to do so, especially with reference to the unsolved matter of nuclear waste. The following two figures evidence this fact where Figure 16 shows that amongst the German population in 2010 a much smaller role for nuclear energy is envisaged in favour of more renewable energy, whilst the British people still seem to envisage a significant future role of nuclear power.

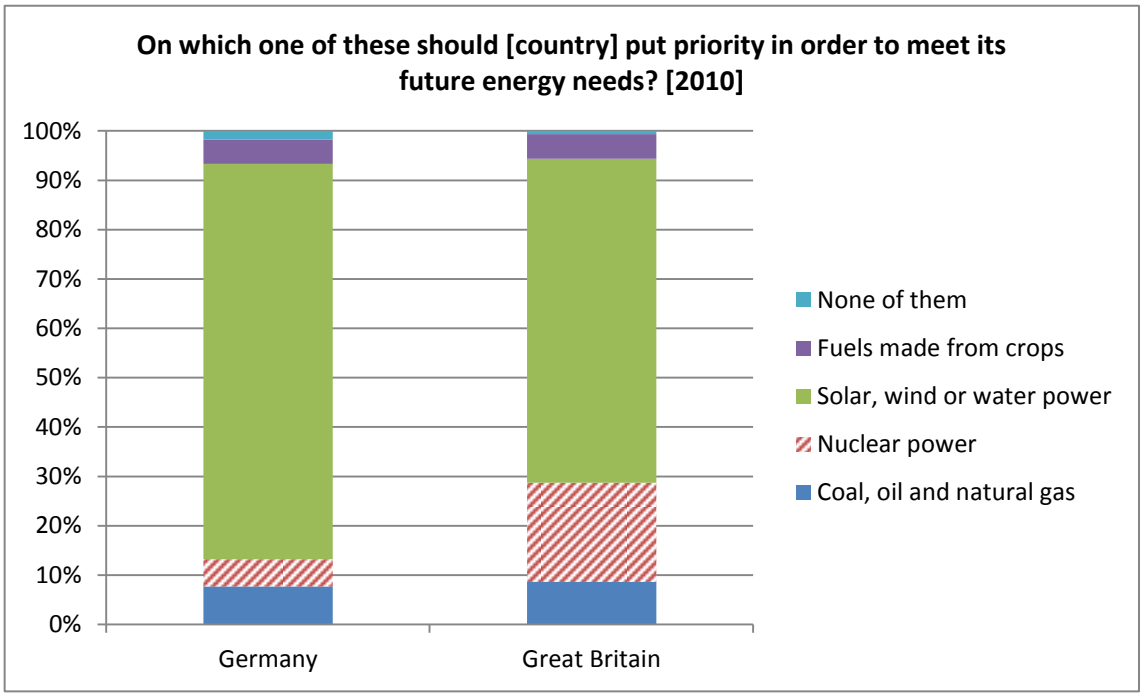


Figure 16: Energy futures Germany vs Britain, 2010 (ISSP Research Group, 2012)

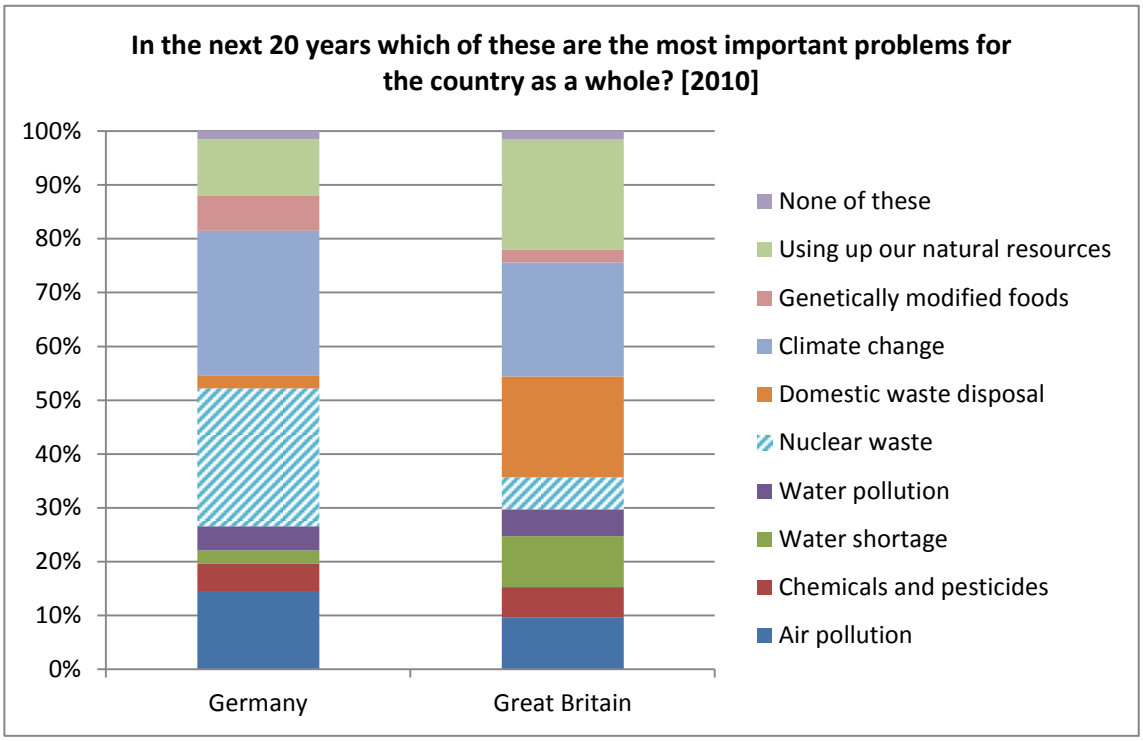


Figure 15: Environmental problems perception Germany vs Britain, 2010 (ISSP Research Group, 2012)

When prompted about the most important environmental problems facing the country as a whole, the German population appears to perceive the matter of nuclear waste along with climate change as the most pressing problems, whilst the British population gives greater importance to the depletion of natural resources, climate change and domestic

waste disposal (Figure 15). Part of an explanation for this difference might be the greater acceptance and therefore diffusion of waste incineration in Germany which provides a technologically advanced solution for the matter of waste disposal which may make it seem like a less pressing problem for the German population. The debate on how to deal with nuclear waste is also very much kept in the public's mind in Germany through press coverage and ongoing debates in parliament about the matter (e.g. Spiegel, 2014).

5.4 CONTEXT FOR INSTITUTIONAL CONSTELLATION

In line with the evolutionary perspective that underlies this study, history is seen as the most important influence on which formal or informal institutions prevail. Events both within and outside of a given area are understood to be influential. The pre-existing inter-institutional constellation filters their effect and impacts on how agents react to those events, whether they cause them to change their attitudes or whether they even re-inforce existing attitudes.

In the present cases, the traumatic experience of the war and the popularity of the environmental movement fuelled German society's fundamental opposition against the use of nuclear power. Britain suffered no comparable trauma and a powerful elite and its close connections with the nuclear industry led to a positive bias towards nuclear energy in government that lasts until today and crosses the parliamentary divide.

[…] there is something within German society – a deep desire to manage without nuclear energy. Because it is apparent in all these surveys, that three quarters of Germans oppose nuclear energy. It has been like that for a long, long time. When there weren't even such strong alternatives.

(interviewee G2)

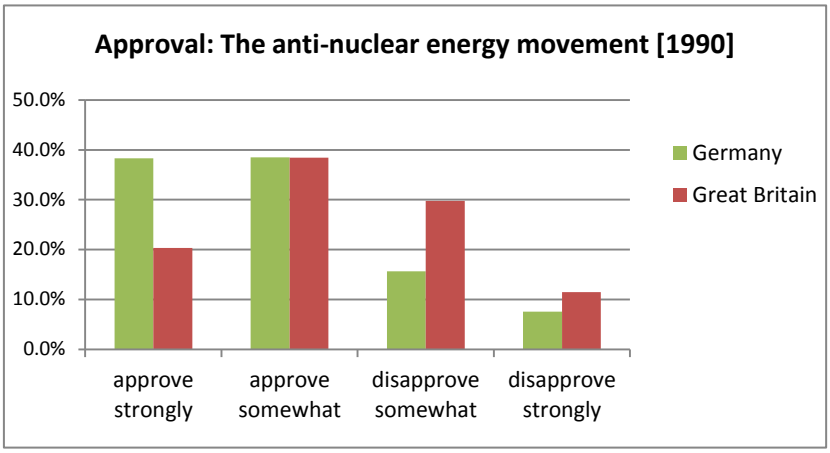


Figure 17: Attitudes towards the 'anti-nuclear movement' (EVS, 2015)

Whilst a sceptical attitude to some extent is evident in both countries, survey data shows a greater strength of sentiment in Germany than in Britain (Figure 17). Although there has been a 'Campaign for Nuclear Disarmament' throughout the years in Britain, this never entered the mainstream in the same way it had done in Germany. Also the group was initially mainly focused on nuclear weapons and included concerns over nuclear power only more recently (Campaign for Nuclear Disarmament, 2016). Some reasons for this difference may lie in the history of the countries. Britain was the first country to develop nuclear power for civil purposes, albeit as an almost accidental side product when producing plutonium for the creation of a nuclear bomb just after World War II (Taylor, 2016). In contrast nuclear energy in Germany was somewhat associated with the National Socialists' quest for power and after World War II the country had agreed not to work on the development of nuclear weapons (Childs, 2001). As part of its power system nuclear power had only been introduced very much top-down by the then minister for nuclear affairs Franz-Josef Strauss in the 1960s (Ohlhorst, 2008). By 1978, however, the German government had highly ambitious intentions for 35 per cent of power to come from nuclear plants. The make-up of opposition against nuclear power in Germany (and France at the time) is described by one energy industry observer as "ostensibly apolitical environmentalists, concerned residents and, in some locations, farmers or fishermen, together with a core of antitechnocratic student activists whose politics vary from liberal to extreme left" (Elliott, 1978, p.119). In contrast he describes what opposition there exists in Britain as dispersed groups of people who attempt to oppose singular projects 'within the system' (e.g. in response to public consultations), with only limited strategies for public

protest and by far not as well connected to each other as their German counterparts. Recently the German government committed to a nuclear exit by 2022 in response to a nuclear accident in Japan in 2011 and following considerable pressure from the civil society (Ohlhorst, 2008).

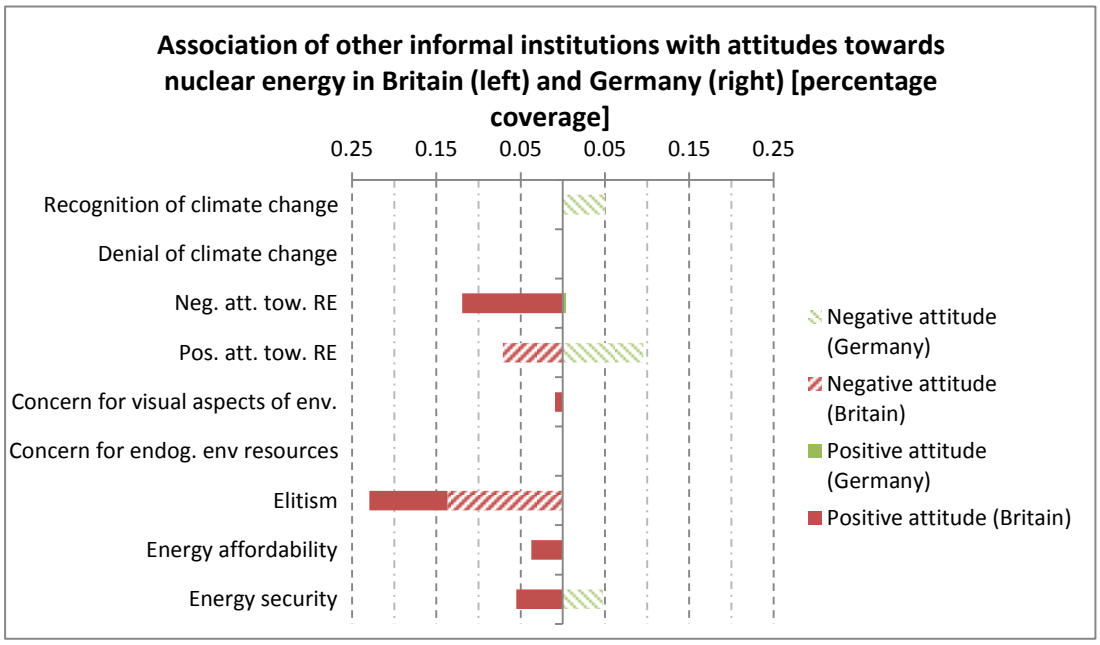


Figure 18: Association of other informal institutions with attitudes towards nuclear power [percentage coverage], own analysis

There is inter-dependency between institutions, not just between the three types of institutions but also between different kinds of informal institutions. Figure 18 shows the most coded other informal institutions with 'attitudes towards nuclear'. The bars on the left side show the values for Britain and those on the right side for Germany. Overall what is clear from this figure is the overwhelming association of 'attitudes towards nuclear power' with 'elitism'. What is remarkable is that this is the case for both positive and negative attitudes towards nuclear power, but also that elitism was only referred to in this context in relation to Britain. Strong associations of the attitudes towards renewable energy with those towards nuclear energy can be expected as well as its inverse relationship, where negative attitudes towards renewable energy are mostly associated with positive attitudes towards nuclear power and vice versa. It appears that in Germany a combination of the recognition of climate change and a concern for energy security may impact on attitudes towards both nuclear and renewable energy. In Britain the strongest association is with elitism, but concern for energy security as well as affordability is also highlighted. The latter does

appear to be less of a concern in relation to Germany judging from the conversations. Whilst there may be an impact of coding technique (partly automated) the main finding from this figure is a significant association of the attitude towards nuclear energy with elitism. This is further corroborated by the qualitative analysis of the content of the relevant passages in the interview data.

The above presented analysis of the interview data implies that elitism is more prevalent in Britain than Germany. Giddens (1974) confirms this further, when he claims that, whilst Britain was the 'cradle of the industrial revolution', it did not experience similar social revolutionary movements as did Germany and France in the 19th century. He therefore assesses that there is a 'ruling class' in Britain that remained relatively continuous and unchallenged even in the course of the 20th century. In the 1960s and 1970s in Britain the nuclear industry had become a popular industry for young graduates to go into as it offered high status and well-paid jobs. One interviewee described the recruiting practice of the brightest (Oxbridge) graduates into the industry. 20 years later these were powerful individuals with close ties to those in government. His account confirms the association of positive attitudes towards nuclear power with elitism further (interviewee B11). Some of the interviewees who participated in this study indicated that they felt that there was a lack of professional expertise amongst British industry management as well as the higher echelons of politics. Childs (2001) also reports that elitism was a strong characteristic of British industry. He describes a study of an American management expert who claimed that "Neither foreign experience, nor legal or technological training, were considered essentials" amongst British managing directors and that "potential success in British industry is quite strongly linked to parental occupation and family status". He sees this in stark contrast to conditions of top management in the United States, Japan, and West Germany (p. 79). The civil service at the time is also criticised for its lack of expertise and experience to make the necessary judgements and decisions for an increasingly complex, (post-) industrial society. A revolving door between the private sector, ministries and the civil service made sure that relationships were close between the two sectors (Childs, 2001). Whitley (1974) provides evidence that large industrial and financial firms in the 1970s recruited their directors from a limited pool of people who would often share social circles as well via prestigious club memberships and kinship links. More recently the strong relationship between elites and government has been analysed in great detail by Jones (2014). He suggests that the media elite in the UK will often work against the interest of the wider population and propagate

policies that reaffirm the existing elite structures or profit incumbents directly and work against any policies that would threaten these relationships.

Interviewees did also suggest a close relationship between incumbent industries, the media, and the political establishment. For example in Britain Bernard Ingham, a well-known figure of the anti-wind movement, was associated with a group that sought to further the use of nuclear energy. He was also Margaret Thatcher's press secretary and interviewees suggested that he would brief journalists deliberately against renewable energy even when this was in conflict with governmental policy.

Bernard Ingham was the guy who effectively started the Country Guardians. And at the time he was also chairman of the society for the nuclear industry. So he, although it was never admitted, he was coming at this with a view that nuclear is great and wind energy is something which is threatening the nuclear industry and should be undermined at all cost.

(interviewee B10)

The anti-wind body became run by a chap called Bernard Ingham who had until recently been Thatcher's press secretary. So all the time we were issuing positive government statements about government's policy - being positive about wind - he was briefing the editors of the newspapers to be negative about it.

(interviewee B8)

[Bernard Ingham] has had a very substantial influence on members of the Conservative party, which obviously had a dampening effect on enthusiasm for wind, when he started to get going. He has backed away from that now, but that has left, within the Conservative party, an ideological issue with wind energy and other senior politicians who have been influenced by that continue to carry that standard forward. They oppose wind energy because they don't like it in the landscape.

(interviewee B10)

Interviewees spoke of a close relationship between incumbent firms and the media in Germany too. Whilst citizens appeared to be largely supportive of renewable energy, incumbent energy companies were for a long period not taking these new entrants seriously at all. They did utilise media to attempt to influence public opinion. Advertising campaigns with a negative outlook on the potential contribution of renewable energy were run. An example is an infamous campaign in Die Zeit newspaper (Illustration 10) which claimed that renewables wouldn't be able to provide more than 4% of the German electricity demand and that therefore nuclear energy had to make a substantial contribution, paid for and signed by a number of large electricity providers. In actual fact renewable energy provided for 32.6% of total electricity in Germany in 2015 and has reached and gone beyond the predicted 4% in the mid-1990s (Deutsche Windguard GmbH, 2015a).

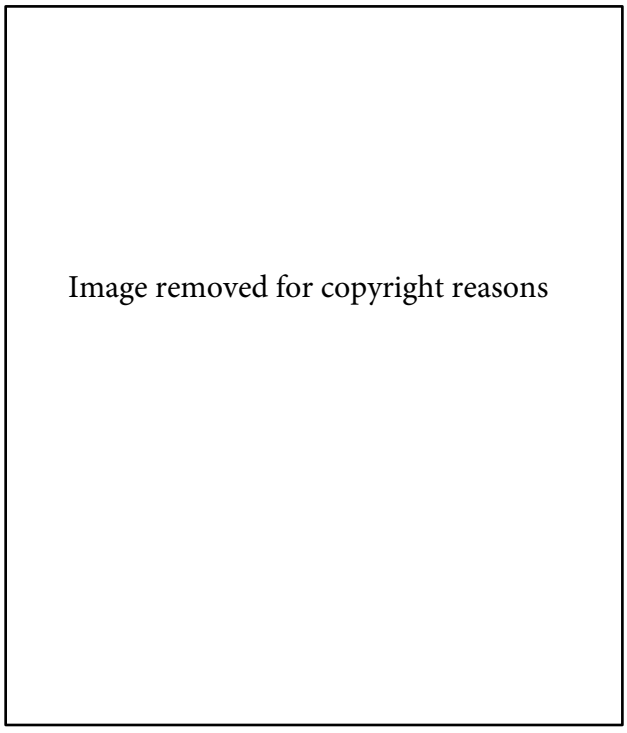


Illustration 10: Infamous Zeit advert on lack of potential of renewable energy (Die Zeit, 1993)

In marked contrast to the findings for Britain, Schmidt (2003) describes a situation in Germany where after World War II a conscious effort was made not to recruit any of the previous political elite and not to let one group gain excessive singular power over the rest of society again. No clear 'establishment class' can be discerned. Germany does not have an equivalent to the Oxbridge alliance of Britain or the Ivy League Universities of the US. Any attempt to change this would conflict with the power interests of the 16 states.

"Neither the German elite as a whole nor the political elite in the narrower sense constitutes a power elite or a distinct social class. It is rather the case that the German elite is post-totalitarian and pluralist in composition, character, and attitude" (Schmidt, 2003, p.185).

The numerical and qualitative analysis of the conversations related to elitism suggests that elites can 'capture' formal institutions thereby impacting on their rigidity and ability to co-evolve with technological development or changing circumstances. In Britain, with more elitist, closed, and hierarchical formal institutional and organisational arrangements, when faced with significant new technological developments in renewable energy and with increasing global recognition of climate change, it took a relatively long time for policymakers to adapt the formal institutional arrangements to put in place support for new entrants to the energy generation sector. Even when this was finally implemented the mechanism (the RO) was designed to favour the incumbent (i.e. elite) firms. In contrast in Germany it appears that lesser levels of elitism and more federal, dispersed and open formal institutional arrangements have allowed new ideas about how energy should be generated to get a foothold amongst policymakers who then acted to put support for new entrants in place, despite the fact that these would challenge the existing incumbent firms.

This shows that the constellation and nature of both informal and formal institutions are important and were different in the two countries. The following section will focus on the relationship of agents with institutions.

5.5 THE STRATEGIC ROLE OF AGENTS

Agents are both restricted and enabled by institutions. Whilst they are restricted by the formal institutional arrangements, they have a capacity in principle to evaluate and amend these arrangements if they see any reason to do so. Internal agents (i.e. policymakers) do have a much greater capacity to change formal institutional arrangements, whilst external agents (i.e. all other citizens) do mainly have indirect influence, which they can exert via the policymaker. Whether or not internal agents use their capacity will depend on how reflective they are in their role and how strong the perceived restriction by pre-existing structures (i.e. institutions) is. If they succeed, the formal institutional arrangements 'co-evolve'. If they fail to act or are too restricted to do so, then institutional hysteresis is likely to continue which may lead to technological lock-in to an existing pathway.

The prevalence of different attitudes can be expected to affect the setting of political priorities. What is seen as crucially important in the case for renewable energy is what is often referred to as the energy 'trilemma', a balance between the concerns that arise from climate change, securing the supply of electricity and the affordability for bill payers (National Audit Office, 2016). It is amongst these different priorities that policy makers have to choose, putting more weight on one or two of the concepts over the other. New ideas entering the policymaking realm via access channels, provided by the informal institutions which impact on individuals' behaviour, may cause a shift in those priorities.

In the late 1980s a lack of gas and oil resources made energy security a high priority for the German government. Increased import dependence was seen as problematic especially in light of the popularity of the peace movement and new investment in nuclear energy was increasingly unpopular reflected in the strength of anti-nuclear sentiment. In a mixture of political deal making, perhaps visionary thinking and pure chance, Germany allowed funding for smaller scale renewable energy schemes in addition to the large scale efforts. The industry consequently grew largely out of these smaller schemes (Ohlhorst, 2008). One civil servant specifically describes some of the mechanisms that were put in place as 'deviating from the rules of innovation policy' and some of their activities as civil servants as 'stretching the boundaries' of what is possible. For example, traditionally, inventors that were not able to prove their creditworthiness would not have been supported, but on occasions where it seemed that truly innovative work was carried out these rules were deliberately interpreted more loosely. One such occasion resulted in support for Aloys Wobben's work on direct drive turbines and consequently in the establishment of Enercon which is one of the best known German wind energy turbine producers globally today (Eisenbeiß, 2012). It appears that regional politicians and civil servants in Germany were aware of technological development and were prepared to support anything which they viewed as potentially profitable for the region in the future. This is evidence of the strong role of the more dispersed federal structure in Germany as an 'opportunity structure' as described by Geels et al. (2014). Attitude surveys also show a certain 'culture of conscious dissent' apparently much stronger in Germany than in Britain. This is strongest in the earliest available survey and becomes less pronounced more recently. It may be a longer term outcome of World War II and Germany's experiences of abuse of authority. This study argues that such attitudes translate into a higher preparedness by agents to 'stretch' or challenge existing rules.

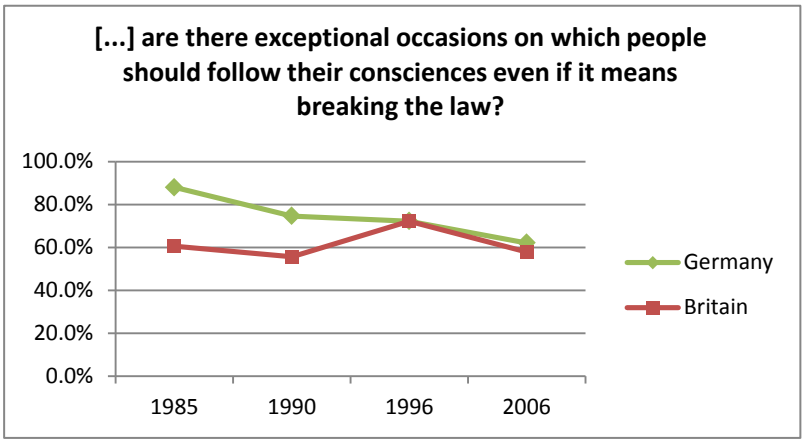


Figure 19: Culture of dissent GER vs GB (ISSP Research Group, 1986; ISSP Research Group, 1992; ISSP Research Group, 1999; ISSP Research Group, 2008)

The first support mechanism for renewable energy in Britain came about as a very small tranche (1% of the total mechanism) of the Non-Fossil-Fuel-Obligation (NFFO) (Taylor, 2016). It may be seen as a matter of contingency as the small tranche of renewable energy support was only achieved through the timely action of a small number of civil servants who, when the mechanism had been proposed in support towards privatisation of the nuclear segment, argued that renewable sources should be included as they are also 'non-fossil fuels'. The civil servants in question acted in support of renewables over the years driven by a strong personal conviction, that this was the way that the energy system was going to have to go eventually. They were up against powerful, vested interests and a constant flow of more or less sympathetic ministers, mostly seeking to maintain the existing, entrenched power structures both in the literal and the figurative sense.

As an individual I thought that Renewables ought to be part of the energy economy. […] So all the advice that I was giving to the government machinery was, you gotta go down this road […]. And eventually we are going to have to make a major contribution. […] And the response you got depended on the personal interest of the minister. Some ministers had an interest, others didn't, but in general we were very small all the time.

(interviewee B8)

Garrad (2012) identifies a tipping point in the early 1990s, where a plateau of smaller scale commercial turbines had been reached and large scale government supported efforts had failed. A European funding programme initiated by Dr Wolfgang Palz, head of RE development at the European Commission, in the late 1980s encouraged existing commercial companies to upscale their efforts to create turbines of MW scale. Garrad

admits that it may be simplistic to attribute the following trajectory of MW development purely to this programme. He does, however, identify it as a crucial turning point for wind energy and praises Palz' vision and strategic skill.

I would say Palz is an unsung hero. He conceived of this WEGA programme. And the vision he had was moving this backyard, semi-commercial stuff into the mainstream. And so he was definitely a visionary.

(interviewee B5)

Hermann Scheer, who was instrumental in the driving forward of the renewable energy vision, and his colleagues are known to have been driven by their personal conviction that this was the 'right' thing to do. In early 2000 the Erneuerbare Energien Gesetz (renewable energy law) was agreed upon. The law is generally accepted to have given the final boost to the German wind energy industry. The policies encouraged further agents to enter the playing field and the stability of a fixed tariff attracted increasingly large investment in renewable energy. Having drafted this law Hermann Scheer is known to have personally defended the mechanism against claims of violation of state aid rules.

Furthermore interviewees see a great advantage in the close relationship between the representatives of the renewable energy industry and working groups within the parliament and assert that this was down to the level-headed and reasonable approach by the particular agents and the shared wider motivation of an energy transition. This resonates with the idea of creating 'common ground' as a strategy of 'institutional entrepreneurship'. Three quarters of all German interviewees (twelve out of 16) mentioned Hermann Scheer as a particularly influential individual. A word search for 'Scheer' was carried out in Nvivo and the surrounding paragraphs were also coded as 'Scheer'. Then the most common words were extracted and translated, and a word cloud was created. It gives an impression of commonly associated terms with Hermann Scheer. The relative size of each term indicates how often it appears in 'Scheer'. The size of 'parliament' and 'parliamentarians' indicate the special history of this law. Especially notable are the relative sizes of the words 'important' and 'green'. Scheer was with SPD, so would have been 'red', but understood to build lasting coalitions with likeminded colleagues from other parties. Again, this resonates with the concept of 'institutional entrepreneurship' where building coalitions across the political divide is an important strategy, pursued consciously or unconsciously.

The most impactful individuals were the band of four from parliament, the four parliamentarians Hermann Scheer (SPD), Hans-Josef Fell (Green party), Michele Hustedt (Green party), and Dietmar Schütz (SPD). […] These were the ones that formed the backbone.

(interviewee G13)

Figure 20: Word cloud Hermann Scheer, own analysis

Interviewees were asked whether there were any particular individuals that they felt were driving forward the development in the industry, both from the industry itself but also amongst politicians. Whereas for Germany interviewees would always mention a small number of the same names (see quote above), interviewees struggled to mention any names for Britain. When probed about this many said that there were no champions for renewables and the wind energy industry amongst politicians in Britain as there were in Germany. Margaret Thatcher was often mentioned as influential politician but not for having a positive effect for the industry but rather as a hindrance. Amongst industry agents Andrew Garrad was pointed out as being one of the most influential individuals.

The word cloud below is the result of the same process as that for 'Scheer' but done for 'Thatcher'. Remarkable are the relative sizes of the terms 'nuclear' and 'industry'. This is most likely because Margaret Thatcher was frequently described as being closely associated with the nuclear industry.

Figure 21: Word cloud Margaret Thatcher, own analysis

The analysis of the relationship between agents and institutions shows the significance of key individuals (i.e. institutional pioneers and leaders) in changing the rules of formal institutions and therefore in institutional co-evolution with technological development or changing circumstances. Agents such as Hermann Scheer in Germany appeared to have been better able to overcome their restrictions and implement changes to the formal institutional arrangements. The shared enthusiasm in their aversion against nuclear energy seems to have been an important catalyst. Comparable agents in Britain did not have the support by a similar general shift in attitudes and thus struggled to overcome their restriction by long established networks, entrenched power structures and vested interests.

5.6 DIVERGENT DEVELOPMENT PATHWAYS

The study argues through the conceptual framework that new paths need for institutional arrangements to develop alongside them in order to be able to join or substitute other paths in the economic landscape. Their success is therefore dependent on institutional co-evolution. Informal institutions impact on whether institutional co-evolution takes place or not through their immediate influence on the perceptions and behaviour of agents. Agents may demand or enact institutional change in response to technological development or changing circumstances. If such change occurs, this is referred to as institutional co-evolution. Where agents fail to demand or implement institutional change, institutional hysteresis is likely to continue or develop. Institutions do not co-evolve and may go on to hinder technological development or even promote development with longer term suboptimal outcomes. There is a risk that this leads to a situation of technological lock-in, where it becomes increasingly difficult to change development pathways.

	BRITAIN	GERMANY
Institutional Change	52.68%	47.32%
Institutional hysteresis	89.63%	10.37%

Table 8: Institutional change vs hysteresis across case countries [percentage coverage, by country]

Table 8 compares the amount of conversation devoted to 'institutional change' against that about 'institutional hysteresis' across the two case countries. This is not an ideal comparison as it does not pitch 'co-evolution' against 'hysteresis' but 'institutional change' instead which is a broader term. A trend is, however, still apparent. Whilst conversation about 'institutional change' is balanced across the two countries, that about 'institutional hysteresis' is referring to Britain significantly more than to Germany. It appears that there is recognition of the need for institutional change in both countries, but interviewees conveyed a sense of institutional hysteresis for Britain in particular. The previous section claims that agents are constrained by the formal institutional arrangements to some extent, but that they also have capacity to change and therefore co-evolve them. On reflection it appears that this has been easier for agents in Germany than in Britain. The formal institutional arrangements seem to be more rigid and less open to new ideas and it is easier for elites to capture institutions and make sure that any changes are in their favour, which is prevented through a greater distribution of power in Germany.

5.6.1 Institutional Co-evolution in Germany

In the present case of the wind energy industry in Germany and Britain a process of institutional co-evolution is apparent in the case of Germany where, in addition to regional support mechanisms, eventually a law was introduced to provide support for the fledgling renewable energy industry. Further institutional co-evolution occurred when the arrangements were adapted, when it was found that the nascent industry needed better support in light of changing circumstances, specifically internationally agreed emissions reduction targets. Whilst there was a range of influential forces, this study has found that the shared sentiment against nuclear power became the uniting motivation for agents across society to act. In addition the federal structure created decentral opportunities to 'trial' new policy options and the system of representation in parliament allowed new policy areas to be established.

The German voting system allows small parties seats in parliament if they get more than 4% of the population's vote, whereas the British first-past-the-post system prevents smaller parties from entering parliament. Whilst Tony Blair reformed the voting system for the European Parliament to bring it in line with other European countries, he failed to do so for the national voting system (Childs, 2001). The system in place inherently favours large incumbent parties and it is therefore unlikely to be changed by either Labour or the Conservatives. The German system, however, allowed the substantial support for the environmental movement and the anti-nuclear sentiment in the 1980s to gradually feed through into the arena of national and regional politics. For example the young Social Democrats would increasingly bring the matter up in discussions and challenge their senior counterparts, but also the Green Party was able to push it onto the agenda (Rave & Richter, 2008; Glaessner, 2005). From a different starting point but also applying intra-party pressure owners of small hydro schemes in the south of Germany with a traditionally conservative affiliation demanded support for their schemes to guarantee their survival. They formed a strong coalition with regional politicians from the North of the country who envisaged that wind energy could transform their economically weak regions (Oelker, 2005). This made sense in Germany because business rates stay in the jurisdiction of the area where the business is located. Thus local authorities see a direct benefit from encouraging business in their area.

When in 1990 a 'commission about measures to protect the earth's atmosphere', consisting of individuals across all parties as well as independent experts, had published its final report recommending international and national measures, including the introduction

of relevant taxes and levies and the modernisation of energy law, the government in power at the time (CDU/CSU – FDP coalition under Helmut Kohl) was less than keen on the proposals. The pressure, however, increased from within, where a younger generation of politicians often shared these concerns with the wider population. At the same time the environmental/peace/anti-nuclear movement became more and more popular and influential. This ultimately resulted in the introduction of the Stromeinspeisegesetz (feed-in law) of 1990 as described in the previous chapter and above. Interviewees pointed out its exceptional simplicity (5 paragraphs on just over one page) and suggest that the government somewhat under-estimated what effect this would actually have.

It was only meant to be a protective law, but what came from it nobody would have guessed. It was only meant to protect the existing small renewable energy sites. They were thinking of the southern German hydro sites, but then to make it look a little less specific they also added in wind energy from Schleswig-Holstein which was in its infancy.

(interviewee G1)

Following Germany's pledge to phase out nuclear energy by 2022 in 2000, it became clear that the feed-in law for renewable energy needed a fundamental overhaul if Germany was to reach its ambitious GHG emissions reduction target (25% of 1990 levels by 2005) (Ohlhorst, 2008). Several interviewees recalled that the ministry for economics was asked to create a draft proposal, but for somewhat dubious reasons (interviewees indicated close ties between the ministry and the incumbent electricity industry) the ministry delayed the proposal. Pressure groups picked up on this, informed parliamentarians about the ministry's inactivity and put pressure on them to take it in their own hands. A group of parliamentarians around Hermann Scheer, SPD, demanded that they were to draft this proposal, which parliament accepted and they did, resulting in the introduction of the Renewable Energy Law in 2000.

And of course we [renewable energy pressure groups] were watching this development closely. And eventually we could inform the responsible parliamentarians […]. We could tell them, you are being misled by the department in this matter. They use wrong numbers – we were able to prove that. So parliament decided that the responsibility was taken away from the department. […] So this law was not formulated by the ministry but by parliamentarians. This was very unusual.

(interviewee G1)

5.6.2 Institutional Hysteresis in Britain

Whilst the above section presents the evidence of institutional co-evolution having occurred in Germany, the case of the industry in Britain looks much different. It seems that in Britain formal institutional arrangements played a much stronger role in determining the fate of the wind energy industry. The following section will show how agents were significantly constrained in demanding and enacting changes to the formal institutional arrangements by the rigidity of pre-existing institutional structures like the organisational set-up of the banking sector as well as the dominant governmental ideology. Incumbent firms were able to maintain their influence on policymaking. New entrants were not encouraged and the power structures in the figurative sense remained unchallenged. This led to the relatively 'undisturbed' path-dependent development of the energy industry in Britain, characterised by contingent events and self-reinforcing factors as described in the previous chapter. The reason for the exceptional development of the RE sector in Scotland is also shown to be part historical accident, part institutional set-up.

Interviewees that were inventors identified a lack of funding as top reason for the difficulty to develop a wind turbine industry in Britain. It emerges that the way that the banking system is structured in a country is highly influential as it has an important impact on funding for smaller scale projects. With the oil price recovering after the oil crises and new sources of gas discovered in Britain, there was no immediate perception of a lack of resource for energy generation and so the funding efforts were discontinued. There was no comparable drive amongst British citizens to individually invest in renewable energy to make up for these lost funding opportunities.

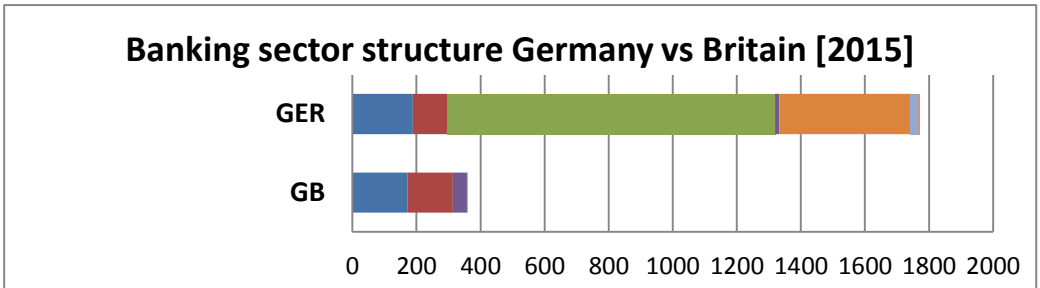
The banking sector in Germany was and is structured very differently from the UK (see Figure 22 on page 172) and cheap credits were available both from the Kreditanstalt für Wiederaufbau (KfW) and from regional and local banks, which both have a specific remit for regional development and sustainability. This has made a great difference for the realisation of many early wind park projects and in turn wind became the main driver of growth for these local and regional banks, which enabled secure credits for further regional projects and thus regional development, forming a virtuous circle (Rave & Richter, 2008). In addition when government funding wasn't available for a project or was reduced a number of inventors were able to secure funding from relatives and friends. This, however, was just not available to individual inventors in Britain and within engineering companies decisions were made at other levels and with other considerations. When the government provided funding it was only given to large scale efforts as the common belief was that only

very large turbines would ever make any meaningful contribution to the British energy system. Hall et al. (2016) analyse the 'finance gap' between Germany and the United Kingdom in detail and come to the conclusion, that it is down to a form of institutional path dependency in the financial systems of the two countries rather than actual 'strategic selectivity' by the state whereby powerful incumbents or the financial sector have lobbied in their favour. They, too, assess a strong role of the 'structure' of the financial system where the "landscape of market based financial institutions [in the UK] is structurally unsuited to allocating capital to small scale renewables" (p.12). Conversely the introduction of the Renewable Energy Law in Germany in 2000 was met by a fertile environment through a banking structure with strong integration with the civil society.

The matter of availability of finance for projects contains both a formal structural aspect, in the shape of the set-up of the banking sector, as well as a question of cognitive paradigms where most policymakers were having difficulty to imagine anything else than large-scale, centralised power generation. This resonates both with Kuhn's (1962) scientific paradigms and with Dosi's (1982) technological paradigms as described in the literature review. Whilst there was a strong governmental focus on large scale in both countries, again, it seems that the federal, more dispersed structure in Germany enabled new ideas about power generation to get a foothold amongst policymakers.

[…]I think that is partly around market set-ups, so that is an institutional question, it's partly also a question around cognitive lock-in of the people who were planning the electricity system in the UK and for them a small-scale, decentralised system wasn't really on the horizon at all. When they were interested in renewable energy, it was […] in bigger scale, maybe utility scale solutions. So I think there is that bias towards large scale centralised solutions.

(interviewee A4)



	GB	GER
Banks	172	189
Branches of foreign banks	141	107
Cooperative Banks		1024
Building societies / Private building and loan associations (Private Bausparkassen)	44	12
Central banks	1	1
Savings banks (Sparkassen)	2	409
Private banks (Bankhäuser)		21
Public sector building and loan associations (Landesbausparkassen)		9

Figure 22: Banking sector structure Germany vs Britain, (Thebanks.eu, 2016)

The British government under Margaret Thatcher (1979 - 1990) put Britain on a decisively pro free market trajectory based on neoclassical economic thinking and largely rejecting regulative involvement of the state. Manufacturing was to be increasingly outsourced to where input factors, labour in particular, were cheaper and thus production costs were lower. The belief in the power of the 'invisible hand' of the market was all encompassing. All of the economy was to be set up to encourage competition as much as possible. Together with Thatcher's disregard for trade unions this undermined the creation of a system of innovation comparable to that of Germany and other developed nations (Childs, 2001). These principles rooted in neo-classical economics (introduced by Thatcher and her government but accepted and continued under Blair's Labour government) meant that there was ideological opposition to supporting fledgling industries before they can compete in a market, merely on the basis of an expected future contribution they may make to the economy. There has been a systematic decrease of British involvement in the production of goods, reflected in an exceptionally negative trade balance to this day (eurostat, 2016c).

	Current Account	Goods	Services
EU-28	0.9	0.3	1.1
Eurozone	2.1	2.4	0.6
Germany	7.6	7.9	-1.3
United Kingdom	-5.5	-6.7	4.8

Table 9: Excerpt of main components of current account balance [2014; % of GDP] (eurostat, 2016c)

Wind was ever so out on the periphery. So having developed and built those machines, most companies were moving away from industry. That was happening in the Margaret Thatcher government in particular. Margaret Thatcher had very little interest in Renewable Energy. The focus of government at that time was moving towards the financial services sector. […] Britain gave very little industrial support money.

(interviewee B8)

A number of interviewees commented that despite her recognition of climate change in a number of speeches towards the end of the 1980s [2] Thatcher had little regard for the Renewable Energy industry. It transpired that said speeches had been prepared by civil servants for Thatcher and are considered to have been requested for the purpose of appeasing the 'green vote' amongst the electorate.

The governments have deliberately promoted and supported innovation through [tax. A]s an inventor I only have to pay 10% capital gains tax rather than 40%, when I sell my shares. That's a fantastic incentive. […] we keep manufacturing, but only in high value industries. Everything else can go to China because we don't make so much money on that.

(interviewee B2)

One interviewee explained that it was quite a challenge to find investors for further development for his inventions or to go into production, but that it would be financially highly advantageous for him to sell the intellectual property rights (IPR) due to the low capital gains tax he pays on this sale. The rights to scale the innovative product up and to distribute it are therefore lost to another person and, it seems for British inventions in particular, often lost to entrepreneurial ventures in other countries. Whilst the sale of IPR may be profitable on the short term, one long term consequence is that employment and any wider socio-economic benefits, that the industry thus created may bring, are lost to the area where the industry is developed. The case of the above quoted inventor is not an

[2] E.g. a speech to the Royal Society in 1988 (Thatcher, 1988)

isolated one but rather it is indicative of a British pattern. The figure below presents the rates of British domestic patents in foreign ownership across sectors. Whilst a tendency of British patents to be in foreign ownership seems to have been a persistent phenomenon for quite a while there was a steep rise from 1986. This is not data that is specific to wind energy related patents but it does map a wider trend.

Because actually […in Germany] the main manufacturers and the main employment are not in the manufacturer's site. They're mainly assembly houses. […] But they have the design, they never let go of the design. They control the innovation. And that's a really important part of the environment.

(interviewee B6)

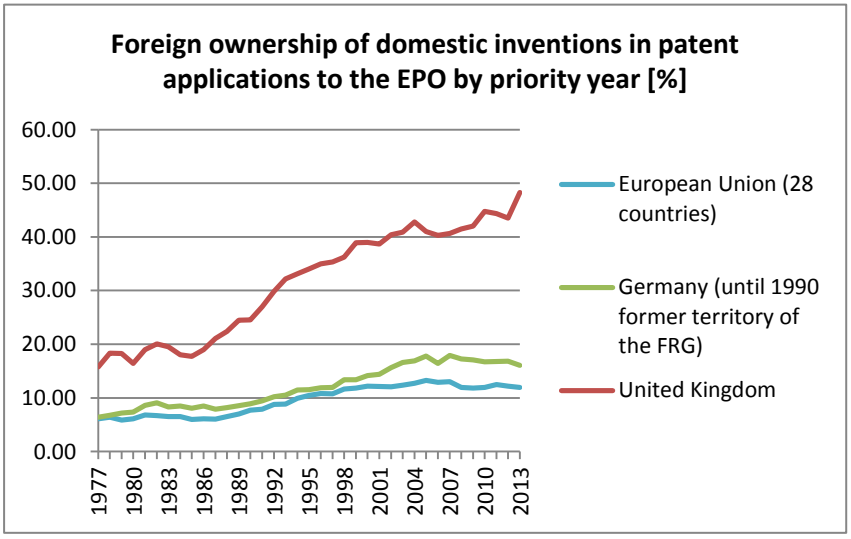


Figure 23: Foreign ownership of domestic inventions in patent applications to the EPO by priority year (eurostat, 2016b)

As part of her economic agenda Thatcher sought to privatise state-owned industries as much as possible. The table below shows the dates and proceeds from Thatcher's privatisation spree in the electricity industry. Interviewees commented that, whilst there had been some intentions for renewables development within the CEGB before privatisation, this was not carried forward into the new organisations beyond take-overs. Reasons may be found simply in the turmoil around the take-overs or in a more short-term orientation over longer term strategic thinking within private business compared to state industry.

This further corroborates the significance of the formal institutional arrangements in Britain, in this instance the importance of the organisational structure and role of the state in the energy sector.

Year	Company	Percentage of equity initially sold	Proceeds [m£]
1990	Electricity companies	100	5,092
1991	National Power and Power Gen	60	2,230
1991	Scottish Power and Scottish Hydroelectric	100	2,880

Table 10: Excerpt of Thatcher's privatisation of public assets (Childs, 2001, p.244)

"The Conservatives argued that they were freeing the taxpayer from the burden of subsidising national assets" (Childs, 2001, p.244). These were profitable companies, although some may have suffered from considerable hysteresis. This process of selling off national assets was not necessarily supported by the public and there was great concern that a lot of these assets were sold off drastically below their price. One observer argued that the privatisation was an exercise in distributing wealth from the taxpayers to the wealthy elite. Many small shareholders of regional companies were subsequently pushed out of ownership by foreign take-overs of the firms causing one small shareholder to comment "We were conned into buying them, now we're bullied into selling them" (Childs, 2001, p.244). Thatcher ultimately also succeeded in her plan to privatise the nuclear industry when 60% were privatised in 1991 followed by the other 40% in 1995 under her successor John Major's government. By 1997 the majority of originally eleven electricity companies were American-owned. Powergen was taken over by the UK subsidiary of German e.on in 2002. Whilst this increasingly foreign ownership of British assets may have brought in foreign capital, new jobs and better management, it can also be argued that vital decisions about technology, output, and products, were made elsewhere (Childs, 2001).

This links with the argument made above about financial encouragement for inventors to sell off IPR in making the case that British inventors will often give up control (enticed by tax arrangements) of their work, leaving it to others to bring it to market and to reap the wider socio-economic profits from it.

Despite privatisation the electricity market remained structured in large scale organisations and focused mainly on fossil fuels. A number of interviewees do, however, identify the privatisation of the electricity companies as important to the development of UK renewables as it did force the industry to be more transparent about the real cost of energy generation and opened up some opportunities for other players. An association of independent power producers was founded. It later merged its operation with the body representing the traditional electricity industry to represent the whole industry and many of

the 'independent power producers' were small wealthy trusts or individuals with a primary interest in their business case, not comparable to the idealistic, grassroots movement that had formed in Germany (Porter, 2014). It is therefore argued that the ownership structure, another form of organisational institutional structure, made a significant difference to the development of the industry in Britain where it was relatively homogenous as opposed to Germany where a wide range of types of owners of wind development sites existed which assisted the creation of a vibrant sector.

A somewhat exceptional case within Britain is that of the regional sub-sector in Scotland. It shows a regional divergence from the national trend in that there is a comparatively vibrant wind energy industry across the supply chain (21% of all wind/marine supply chain companies in the UK – see Figure 24 on page 177) and there is significant diffusion, reflected in the installed capacity. Interviewees identified the reason for Scotland's regional divergence from the national trend in Britain as historical. Scotland is primarily agricultural with a traditional sense of understanding scarcity of resources and a thus derived pragmatism in the use of those resources. In combination with a political need to occupy new fields after devolution via the Scotland Act 1998, this led to the creation of a highly beneficial environment for this industry to develop in Scotland. For example in the recent years funding for research into wind energy has been re-established and centres of excellence in research have been developed, e.g. at University of Strathclyde in Glasgow.

I wouldn't like to say that the strength of opinion on climate change is strong in Scotland compared to other parts of the world. If anything, it's probably a bit weaker because we're a cold country and the idea that the world is warming up doesn't really horrify too many people.

(interviewee B12)

Dawley (2013; 2015) has studied the historical development of the wind energy path in North East England and Scotland as part of a wider political aim of re-industrialising the north of England. He points to the benefit of multi-scalar and multi-agency analysis to provide a comprehensive understanding of regional economic development beyond merely firm focused accounts. His particular emphasis is on the role of a stable institutional environment. He uses the case of the offshore wind energy path in the North East of England to illustrate the benefits of institutional consistency and stability over time. Following the formation of a Conservative – Liberal Democrat government in 2010 the Regional Development Agency for the North East, which had identified the offshore wind energy sector as a 'central pillar' was abolished and control over innovation funding was centralised and mostly focused on Scotland. This created a 'policy vacuum' in the North

East of England with detrimental effects for the region's economic development in general and that of the regional supply chain industry in particular (Dawley, 2013). At the same time the devolved Scottish government maintained its firm commitment to the renewable energy industry underpinned by highly ambitious targets, for example generation of 100% of the country's electricity consumption from renewables by 2020. A broad policy approach focused on various aspects of both path creation and path development in combination with strong regional governance fostered a beneficial environment leading to the establishment of a vibrant regional industry and supply chain in Scotland, characterised by a mixture of indigenous path creation and foreign investment (Dawley et al., 2015).

Although Scotland appears to be an outlier to the development in the rest of Britain it provides further evidence of the potential strong role of both formal and informal institutional arrangements. The political need to differentiate Scotland from the rest of Britain combined with the historically grown pragmatic attitude of making the best of the available resources led to its divergent industrial development.

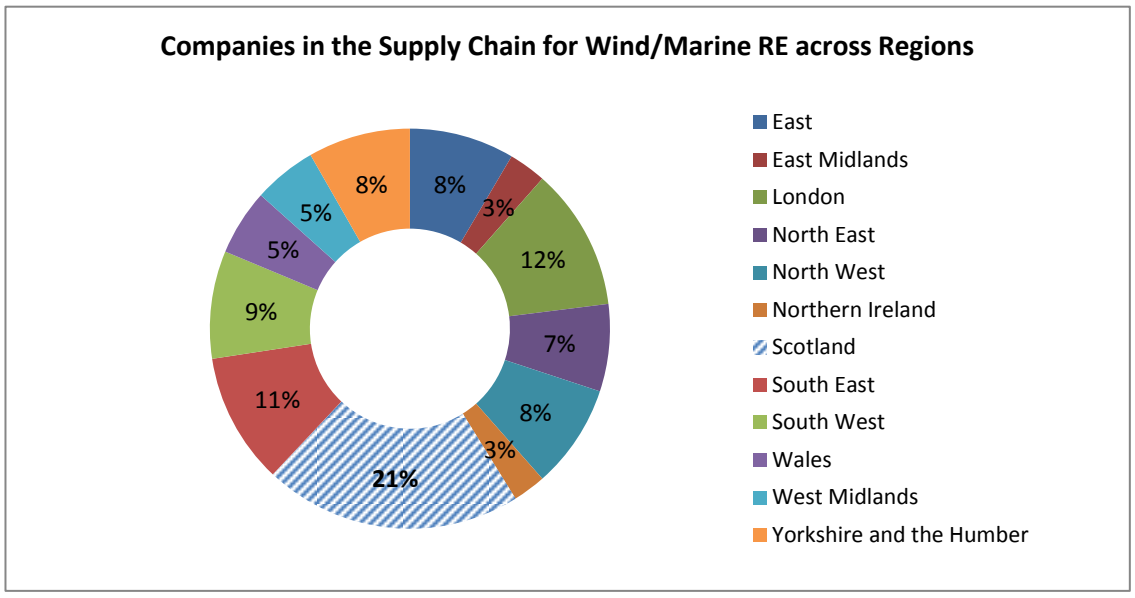


Figure 24: Companies in the supply chain in regions according to RenewableUK (RenewableUK, 2016)

Even when a new mechanism, the RO as described in the preceding chapter and sections above, was introduced in the early 2000s it was not designed to encourage new entrants but ensured the maintenance of the position of incumbent firms. This was due to the lack of any real commitment to challenge the existing power structures or even to renewable energy itself by a government that was about to put new nuclear power back

onto the agenda of the energy policy debate (Mitchell, 2008). Whilst the Energy White Paper of 2003 still declared that the government has no intention to build new nuclear as long as the issue of nuclear waste is not resolved, there was a drastic change of tone when in 2006 the Energy Review laid out the argument for new nuclear in great detail (Department of Trade and Industry, 2003; Department of Trade and Industry, 2006). Reasons for this change in strategy remain dubious at this point although a recent report by SPRU at the University of Sussex documents enhanced activity concerning the maintenance of the nation's nuclear submarine program and suggests that this may be one explanation for the government's apparent bias towards nuclear (Cox et al., 2016). Interestingly the House of Commons' own Environmental Audit Committee in its Sixth Session Report in 2006 finds strong words of criticism for the government for its lack of commitment towards its own longer term energy strategy and an apparent refusal to consider other options beyond new nuclear power (House of Commons - Environmental Audit Committee, 2006).

This suggests that other interests prevailed in Britain over the concern about the long term consequences and costs of nuclear waste which remains the primary concern in Germany with regards to future energy pathways. It is therefore argued that formal institutional arrangements and their capture by vested interests played a more significant role in Britain than in Germany.

5.7 OUTCOME

The particular institutional constellation and the evolution of that constellation over time have a crucial impact on where, when and how industries develop. This is because the institutional constellation influences agents' scope for action and therefore their capacity to change and co-evolve institutions themselves. Where agents find themselves able to demand or enact changes of the formal institutional arrangements these may co-evolve with technological development or in the light of changing circumstances to accommodate or support new ideas and practices. Where agents do not perceive a necessity to change the formal institutional arrangements or find themselves constrained to do so the institutions will continue to evolve in a path dependent manner with a tendency towards hysteresis. Likewise the economic landscape is likely to continue to develop in a path-dependent manner, characterised by contingency and self-reinforcement, biased towards incumbents and with a tendency towards technological lock-in.

The case of the wind energy industry in Germany has shown that because of the widespread aversion towards nuclear power agents across society (inventors, citizens, policymakers, business leaders) felt empowered to demand and enact changes to the institutional arrangements and make them thus co-evolve with the technological development in renewable energy, which facilitated the rapid growth of the wind energy industry. This was possible because those formal institutional arrangements in Germany are sufficiently malleable and the power sufficiently dispersed to allow for new ideas to get a foothold amongst policymakers. As a result of the shared sentiment the policies remained in place and endured even political change. The consequence is an electricity industry that has been challenged by new entrants and has had to adapt to new challenges. Certainly up until 2010 it remained dominated by small and medium enterprise, where socio-economic benefits stayed in the region and country.

In contrast in Britain vested interests successfully captured the institutional constellation over a sustained period and made sure that existing arrangements stayed in place as much as possible. A similar shared sentiment could not grow to the same extent and could not get a foothold amongst policymakers. Agents did not feel the necessity to change the formal institutional arrangements or were constrained to do so by conflicting interests. Existing power structures and vested interests in the electricity industry were thus allowed to continue to evolve relatively undisturbed resulting in an industry dominated by large firms that are often governed from elsewhere and in a complete lack of turbine producers as those that did exist were not able to secure sufficient funding from either the government or individual sources at the time.

It has been shown that the institutional constellation in Britain and Germany differs significantly in terms of its openness towards new ways of thinking and the distribution of power, which has had a crucial impact on the formation and development of the wind energy industry in the two countries. For new path creation and consequent technological transition it is important that new attitudes and values can enter the institutional arrangements. These are typically born in the informal rather than the path-dependent formal institutional realm. Given its historically grown more hierarchical, more centralised structures which are often captured by powerful elites, Britain tends not to allow access to the formal institutional arrangements to such new attitudes and values, whereas Germany does due to its more dispersed, federal structure. In combination with a different resonance of the environmental and peace movement in the two countries this leads to a divergence in longer term industrial and socio-economic outcomes. Therefore it is argued that formal

institutions played a greater role in Britain in their hysteresis and resistance to change, whereas informal institutions played a greater role in Germany in providing avenues for new attitudes and values into the formal institutions and thus facilitating institutional change.

6 Conclusions

6.1 INTRODUCTION

This final chapter is structured in two parts. The first part summarises the key findings and relates them back to the aim and objectives, the hypotheses, and the research questions that were formulated. The second part reflects on how the study could be taken forward, on its potential impact and on implications of the findings for economic geography, regional development and policy.

The following first part illustrates how the aim and objectives were achieved through this thesis. It then explains why and how the hypotheses were both confirmed by the insight from the fieldwork. Then, the key findings about the role of institutions for the path dependent development of the wind energy industry are summarised. The structure of this section reflects the research questions. It explains how different kinds of agents gained influence on the formal institutional arrangements, states the key factors that facilitated institutional co-evolution, and restates that it was found that informal institutions can provide access channels to policy for new ideas. Finally it shows how formal institutional arrangements in Germany with power more dispersed and less centralised were found to be more favourable towards new technological trajectories and institutional change than those in Britain.

In the second part of the chapter the contribution to knowledge is made explicit and the limitations of this study are reflected on. Thoughts are offered on lessons that can be learnt for research in the economic geography field and on implications for policy in regional development. A further section discusses how this study could be taken forward, suggests potential research avenues building on the contribution from this thesis and on the existing body of knowledge. The final section reiterates the key theoretical findings and summarises the most important aspects of the case study and its implications.

This last chapter is followed by the bibliography which lists all the quoted sources and an appendix with further material from different stages of the fieldwork process, which is referred to throughout the thesis.

6.2 AIM AND OBJECTIVES

The following has been the overarching question to this thesis. From this both the aim and objectives were derived. They can be found in chapter 1 in section 1.3.

Why did the wind energy industry develop earlier and to a greater extent in Germany than in Britain?

In the early stages of the research for this study an aim and a set of seven objectives were developed. This section discusses the aim and each objective individually and explains how they were addressed in the thesis.

The thesis presents an in-depth investigation of the uneven development of the wind energy industry with specific regard of the role of institutions. The study unites a path dependency approach with a focus on institutions. Two **frameworks** are proposed that enable to investigate the relationship between institutions and path dependent techno-industrial development and the role of different kinds of institutions for such development. It is shown how both formal and informal institutions influence whether institutions co-evolve with technological development and changing circumstances. Both frameworks have led to the choice of particular methods to investigate the uneven development of the wind energy industry in Germany and Britain. A **sequential mixed methods approach** was used where the analysis of quantitative data was followed by that of qualitative data in order to gain insight and explain the observed phenomena. The emphasis was put on qualitative data. A short **pilot study** consisting of interviews with four academics served to test the questionnaire and to adjust the scope of the study. It led to a greater focus on the role of institutions in the framework and to an improved questionnaire. For the **main fieldwork** a small set of quantitative indicators was assembled and 32 in-depth interviews were carried out in Germany and Britain with experts from across the wind energy scene. A broad range of perspectives was covered by the respondents. All the information has been **analysed** and presented coherently in two chapters. One analyses all available data primarily from a path dependency perspective and one focuses on the role of institutions. The framework has been **continuously improved** throughout the process leading to the **conceptual framework and analysis framework** that have been presented in the literature review of this thesis.

6.3 ADDRESSING THE HYPOTHESES

The following section addresses the two hypotheses that were presented in answer of the overarching question why the wind energy industry developed earlier and to a greater extent in Germany than in Britain. The hypotheses can be found in full in chapter 3 in section 3.3.2.1 and the detailed analysis can be found in chapters 4 and 5. A summary of the findings will also follow in section 6.4 of this chapter.

6.3.1 Confirmation of the First Hypothesis

The first hypothesis has been confirmed because it has been shown in chapter 4 that in the present case of the wind energy industry in Germany and Britain the economic landscape naturally evolved in a path dependent manner, characterised by contingent events and self-reinforcing mechanisms. The hypothesis suggests that institutional constellations filter the perceptions of agents of technological trajectories and changing circumstances, which enables agents to co-evolve formal institutional arrangements or not. Different institutional constellations between countries may therefore explain divergent development.

The analysis has provided insight on this mechanism. It has been shown how both formal and informal institutions influenced agents' perceptions in Britain and Germany. Agents in Germany were open to perceive important technological development and changing circumstances and prepared to act on them by demanding, instigating and carrying out amendments to formal institutional arrangements and thus co-evolving them. Agents in Britain struggled to carry out such amendments or were even prevented from perceiving a need to do so in the first place and institutional hysteresis continued. The difference in the institutional setting is therefore seen as one crucial part of the explanation of the divergent development pathways between the two countries. Further detail on the role of individual types of institutions is provided through the comment on the second hypothesis below.

6.3.2 Confirmation of the Second Hypothesis

The first part of the second hypothesis is confirmed because it has been shown in chapter 5 how the shared attitude towards nuclear power in Germany provided an access channel for new ideas about how to generate energy to get a foothold amongst policy makers. This shared negative sentiment moved agents across society to become active and demand or implement changes to the formal institutional arrangements in support of alternative means of energy generation. It also helped to sustain such support beyond political changes. New

path creation and consequent technological transition was thus supported by these new ideas entering the formal institutional arrangements via the access channels, provided by the informal institutional realm. There was no similar strength of sentiment in Britain, where formal institutional arrangements had a more restricting role compared to their enabling role in Germany. Further detail on this aspect is provided below.

The second part of the hypothesis is confirmed because it has been shown in chapter 5 how the degree of rigidity of formal institutions impacted on agents' perception of technological development and changing circumstances in Britain and Germany. The federal structure with more dispersed power in Germany proved to be more open for new ideas and enabled external and internal agents to demand and implement respectively institutional support for a fledgling renewable energy industry in response to technological progress and an increasing consideration of the global challenge of climate change. The more rigid, closed and hierarchical structure with power highly centralised in Britain, however, hindered agents in their ability to co-evolve institutional arrangements or even perceive a need to do so. Historically grown elite capture of organisational forms of institutions and the media helped maintain existing power structures in every sense.

6.4 THE ROLE OF INSTITUTIONS FOR THE DEVELOPMENT DIVERGENCE

The following section is a summary of the findings of this study with reference to the research questions which had been derived from the hypotheses and the conceptual framework. They are specified in section 3.3.3 in chapter 3, Research Design & Methods.

6.4.1 The Influence of Civil Society Agents and Firms

A wide ranging societal shift in attitudes is likely to eventually feed into the policy arena, not only because politicians are citizens themselves but also because they can be held to account by citizens. Citizens may either seek to influence policymakers individually or they can organise themselves into social movements, where they bundle their common resources to gain more power. This happened in the example of the anti-nuclear and environmental movement in Germany where eventually parliamentary representation was achieved through the Green party (Glaessner, 2005). Citizens had made their voices heard in well attended protest camps against planned nuclear plants since the late 1970s and in response to the transport of nuclear waste across Germany between storage sites in the 1990s (Kriener, 2016). Pressure groups also made a group of German parliamentarians

aware that the ministry deliberately delayed the re-drafting of the renewable energy law in the late 1990s, encouraging them to take matters in their own hands, which eventually led to the drafting of the Renewable Energy Law of 2000 by parliamentarians (interviewee G1).

Incumbent firms seek influence via lobbying policymakers but they also seek to influence the general public via the media. Evidence for this has been found in both countries. Interviewees have primarily associated lobbying with private incumbent firms and have mentioned examples of campaigning with a concrete intention to influence public opinion in favour of nuclear power in Germany (e.g. advertisement in Die Zeit newspaper). An example in Britain may be influence taking via individuals close to government like Bernard Ingham (former press secretary to M. Thatcher). It is also well established that there is a historically grown close relationship between political and economic elites in Britain (Whitley, 1974; Childs, 2001; Jones, 2014).

The formal institutional arrangements in Germany were sufficiently open for new ideas about energy generation to get a foothold amongst policymakers. The federal structure and dispersed power provided an 'opportunity structure' to try out new pathways (Geels et al., 2014). The increasing strength of the anti-nuclear sentiment and popularity of the environmental/peace movement in Germany across society meant that policymakers were increasingly open towards alternative means of energy generation. The movement entered organisational forms of institutions via the parties' own youth divisions (Rave & Richter, 2008). No comparable strength of sentiment existed in Britain and instead interviewees suggested that conservatively minded pressure groups, run by well-connected individuals, were able to influence policy in favour of conventional means of energy generation (interviewee B10). Again, a close connection of the economic with the political elite is likely to have strengthened the influence of incumbent firms on policymakers in Britain. Aspects of the formal institutional arrangements in Britain like the voting system delayed the entry of new political fields into parliament as it is very difficult to enter parliament for new parties.

6.4.2 Drivers of Institutional Co-Evolution

The key factor for institutional co-evolution in support of alternative means of energy generation was the degree of rigidity of formal institutional arrangements in combination with the presence or absence of strong emotive factors. This is argued to be primarily historically determined. History, including both events from outside an area as well as events within an area, crucially influences which informal institutions may form and prevail.

Interviewees pointed to the influence by events of global importance, like the nuclear accidents at Three Mile Island, Chernobyl and Fukushima, on public attitudes especially in Germany. This was also supported by attitude surveys which showed a weaker strength of feeling amongst British people. Despite their global impact events were perceived differently in different places. This study argues that this was due partly to different institutional settings. A further important influence was the local reporting of events which in Britain was shaped by a more biased media as suggested by Childs (2001), Jones (2014), and Poortinga et al (2014).

In Germany a less rigid and hierarchical formal institutional structure allowed agents to continuously evaluate and amend formal institutions. Evidence for this is the continuous support of wind energy and other renewable energy technologies on the national level since 1990 and the regular review and amendment of policy within the wider framework of support of renewable energy. In Britain agents were prevented from doing the same or even perceiving a need to do so by more rigid and hierarchical institutional structures. Even where civil servants were personally convinced that more needed to be done in support of renewable energy, they were up against strong vested interest and lack of continuity in the light of political change (interviewee B8). When supportive institutional arrangements were put in place, they were designed to favour incumbent firms rather than encourage new entrants. This is argued to be due to a lack of true commitment to the cause of an energy transition amongst British policymakers and due to the capture of formal institutions by economic elites (Mitchell, 2008).

In addition the strong sentiment against nuclear power in Germany provided an important access channel to the institutional arrangements as it moved agents across society to reconsider the arrangements in place and to demand changes:

Attitudes and values affect the engagement and investment by the general public with and into new technologies. This leads to a level of emotional 'buy-in' causing higher acceptance and faster adoption of a technology. If they are strong enough, informal institutions can become motivational drivers for action for individuals. The main example for this is the shared sentiment against nuclear energy, which drove inventors in Germany to seek alternative solutions, and drove citizens to invest individually in wind energy projects and to attend demonstrations and change their voting behaviour, helping the Green party to enter parliament. All German interviewees and just under half of the British interviewees mentioned the anti-nuclear sentiment as an influential factor for the wind energy industry development.

Policymakers are citizens and reflective agents who carry norms, values, and attitudes. The prevalence of different informal attitudes affects the setting of political priorities. In the present case this is the balance being struck amongst the three aspects of what is known as the energy trilemma (energy security, energy affordability, climate change). A fundamental shift in attitudes can force a change of priorities. This is because, as explained, policymakers are citizens themselves but also because pressure will be exercised on them from both the civil society and the incumbent firms to act in their interest. An example is the increasing strength of sentiment against nuclear power in Germany and associated pressure from the civil society, which eventually led to the pledge of a complete nuclear exit in 2011 (Rosenkranz, 2016).

The industrial landscape is more indirectly affected by informal institutions. Changes of the formal institutional environment are likely to have the biggest impact on business practices as is illustrated in the conceptual framework of this study. Such regulative changes, however, are often the result of shifts of attitudes, as explained above. Furthermore the consumer carries considerable power whereby, through coordinated action, firms can be put under pressure to change their practices or development direction. One interviewee specifically referred to the fact, that they did not want to seem to be 'behind' as an organisation and thus refocused their activities onto renewable energy and sustainable business practices (interviewee G7).

Both institutions on different scales and different kinds of institutions are inter-dependent, meaning that a change of one will have an impact on the other. As explained above the shift to strongly negative attitudes toward nuclear energy in Germany eventually forced a shift of priorities in policymaking, so a change in informal institutions led to a change of the formal institutional arrangements. This is the most important evidence of inter-dependency between different types of institutions in the present case of the wind energy industry in Britain and Germany. Having begun this virtuous circle (or self-reinforcing mechanism) changes like the ministry of the environment (organisational form of institutions) becoming the responsibility of the Green party in Germany in 2002 led to further increased support for renewable energy in general and wind energy in particular (via formal institutions through investment and campaigning). The ministry's investment in educational campaigns and important research projects on the impact of fossil fuels led to even more support for alternative means of energy generation amongst the population and thus further reinforced the virtuous circle.

In the case of Germany the existence of well-established regional institutions, the Länder, also provided an 'opportunity structure' where new ideas could be introduced and developed, where technologies could emerge (Geels et al., 2014). Regional economic interest can provide a strong motivation for the support of technologies, as has been shown to be the case for the structurally weak Northern Länder in Germany, where the young wind energy industry received early support. This is only possible where the formal institutional structure allows for it – business rates in Germany stay in and benefit the area. The ongoing concern for whole regions of Germany which are relying on coal production is an example for how such regional economic considerations can slow down a transition process.

6.4.3 New Ideas Reach Policy Makers via Informal Institutions

New ideas about alternative forms of energy generation entered the political realm via access channels provided by the informal institutions, the shared sentiment against nuclear energy in particular. This led to a greater acceptancy of the need to support wind and other renewable energy technologies in order to facilitate a transition to renewable energies as part of a wider strategy to protect the environment. Although government was not keen initially there was sufficient pressure from individual parliamentarians and regional politicians to implement such support. A great variety of agents (farmers, engineers, landowners, environmental activists, regional politicians, entrepreneurs, etc.) could unite behind the shared sentiment against nuclear energy although they did not necessarily share other motivations.

Within organisational forms of institutions there also appears to be such a thing as 'organisational culture' which determines what is considered 'normal' and translates into behavioural norms and common practice. For policymakers this determines what level of state involvement is expected and which kinds of deals are considered acceptable. Attitude surveys have shown higher levels of preparedness for 'conscious dissent' in Germany, which may explain a greater tendency to stretch rules in order to give the best possible support for wind energy (ISSP Research Group, 1986 – 2008; Eisenbeiß, 2012).

Informal institutions and the access channels to institutional arrangements they provide were not found to be of equal importance in Britain as in Germany. There was no comparable strength of sentiment which could have united agents in the same way. Instead the formal institutional arrangements appeared to be more constraining. Further detail is provided below.

6.4.4 Formal Institutional Arrangements Restrict Agents in Britain

The formal institutional arrangements were found to be primarily constraining to agents in Britain. Because of aspects of the institutional set-up like the voting system, it is more difficult for new political fields to enter the political realm and for new parties to enter parliament. Innovative engineers were not able to find the financial support that would have been necessary to industrialise their inventions. Neither did the government support the fledgling industry continuously nor were they able to benefit from support from emotionally driven individuals like their German counterparts. In addition it transpired that due to tax arrangements it was more profitable for inventors to sell on their inventions than to seek to develop, scale up and industrialise them themselves (interviewee B2). Such sales often meant that technologies were bought up by investors from other countries including Germany. Britain was found to have exceptionally high rates of domestic patents in foreign hands amongst EU countries (eurostat, 2016b).

Civil servants that understood the need to support the renewables industry were up against a constant stream of more or less sympathetic ministers and historically grown vested interests within Whitehall (interviewee B8).

6.4.5 Formal Institutional Arrangements in Germany More Open to New Ideas

The federal set-up and the more dispersed power structure in Germany were found to have an enabling effect on agents. On the regional level politicians were well aware of inventive activity in renewable energy and, via the parties' youth divisions, the issue of the need for an energy transition increasingly entered the agenda. Politicians from the Northern Länder also understood that a wind energy industry could potentially transform their structurally weak regions. This was possible because business rates stay in the area where they are generated in Germany. Once the anti-nuclear sentiment had reached vast parts of the German society including the political sphere, the state did not hesitate to invest in original research on alternative energy generation methods and on the impact of conventional methods (interviewee G14). Furthermore, in collaboration with the RE industry, specific skills training programs that would serve the industry were set up at universities and higher schools. Much of this was possible because the Green party participated in governments on both the regional and the national level from the mid-1980s. On the national level they obtained power over the ministry of environment and therefore the matter of renewable energy in 2002. This led to a further increase of investment in research programs in the

environmental and social consequences of continued use of fossil fuels and nuclear power as well as original research into alternative options including wind energy (Glaessner, 2005; interviewees G12 and G14).

6.5 WIND ENERGY – THE CURRENT STATE OF THE PATH AND FUTURE CHALLENGES

For reasons of data manageability and focus this thesis has concentrated on the period between World War II and 2010. More recently the dynamics in and around the industry have shifted. This is discussed to a limited extent as part of the analysis. The following section gives a short overview over the current state of the industry and comments on key future challenges to the path in each case country.

6.5.1 The State of the Industry

The wind energy industry is now widely seen as a key contributor to a green growth path (European Wind Energy Association, 2012). Wind energy is set to become the largest contributor to the European power mix, having overtaken fuel oil in 2007, nuclear in 2013, hydro in 2015, and coal in 2016. Natural gas retains the largest share at the time of writing (Wind Europe, 2016). A total of 44.2 % of all new power capacity in Europe in 2015 has been wind power (nearly three times as much as coal). Germany is still leading Europe with a total of 45 GW of cumulative installed wind capacity. Spain remains second with 23 GW and the UK (13.6 GW) and France (10.4 GW) are close third and fourth. The relevance of offshore wind increases steadily. It accounted for 24 % of European wind power installations in 2015. Whilst the UK has seen rapid development in offshore in recent years Germany has also trebled its installations offshore in 2015 compared to 2014 and is now the second largest European offshore market. The UK government has signalled intentions to reach 10 GW of offshore wind installed by 2020 (double the cumulative capacity in 2015 of just over 5 GW) if the industry manages to reduce costs significantly. The German government has signalled an intension to reach a target of 11 GW of offshore capacity by 2025 (European Wind Energy Association, 2016; Global Wind Energy Council, 2015).

6.5.2 Employment

Direct employment in the wind sector in 2010 was at 135,863 full time equivalent jobs in Europe with the largest share being employed in wind power manufacturing. An additional two thirds of that is estimated to be employed indirectly (in the supply chain). Between

2007 and 2010 there has been a growth of nearly 30 % in employment in the wind sector while EU unemployment rose by 9.6 %. In the same period company taxes paid increased by 50% and employees' income taxes increased by 41.5 % (European Wind Energy Association, 2012).

Being amongst the first movers and therefore a leading market for a substantial period has brought great socio-economic benefit for Germany where an estimated third of all renewable energy systems related employment in Europe is located (European Commission, 2014). For Germany 'gross' employment numbers for wind (i.e. direct and indirect – including the supply chain) are reported as ca 121,800 for 2013 and ca 137,800 for 2014. Despite some uncertainty in the home market the relative competitive advantage and high quality of German wind energy products in the international market as well as the increasing significance of operations & maintenance expertise means that the growth of the sector can be expected to continue (Lehr et al., 2015). In Britain the gross employment figure for 2015 is estimated to be 30,599 full time equivalent individuals for the wind energy sector. Sub-sections of the industry experienced a slight decline of employment numbers. Reasons for this are understood to be reduced government support and resulting uncertainty. Once the industry has adjusted to changes in the policy environment the employment numbers are expected to rise again (RenewableUK, 2015b).

6.5.3 Regional Development

Since none of the initial manufacturers of wind turbines survived in Britain many of the components of wind turbines installed are sourced from other countries, often from German companies. Since 2010, however, as a consequence of the vast investments into offshore wind energy by the British government a significant supply industry has established in Britain. Whilst the turbines themselves still tend to be imported a number of companies now supply towers and components. National benefits are limited in the construction phase of UK wind turbines with only about 45 % of investment remaining in the UK, whereas both in the development and the operations and maintenance phase more than 90 % remain in the UK. Local and regional benefits are most significant in the operations & maintenance phase with 65 % staying in the region compared with 41% and 29% for the construction and the development phase (RenewableUK, 2012). RenewableUK estimates that in onshore wind construction offers around 2.49 jobs per MW, compared to 0.54 in development and 0.43 in operations and maintenance. This suggests that relatively small changes in the shares of investment in construction locally, in

the region or nationally would yield significant employment benefits. The government has identified this as a key area of improvement (RenewableUK, 2015a).

Initially structurally weak regions especially in the north of Germany have managed to turn the global threat of climate change into a local opportunity. Sub-regions like that of Nordfriesland in Schleswig Holstein identify the energy industry and wind in particular both in manufacturing and deployment as the source of their advantageous socio-economic situation (Lamers et al., 2011). Rave and Richter (2008) quote an income from business rates (which stays with the local authority in Germany) from wind energy of on average around €10,000 per MW/year and up to €13,000 per MW/year in good locations in 2007. For the whole of Schleswig Holstein an amount of about €20m is estimated, the majority of which is achieved in the previously structurally weak coastal sub-regions. Just wind energy in some sub-regions of Schleswig Holstein accounts for about 5% of business rates with some local authorities like Husum achieving more than 50%. Beyond business rates investments of around €600m to €700m per year (excluding offshore investments) are made in and stay in the region. Around a third goes to regional engineering and construction companies whilst the other two thirds are development costs and income tax (Rave & Richter, 2008). Many businesses in traditional industries, for example shipbuilding or heavy machinery, were struggling in the early 1990s and were able to change their destiny and save their employees by diversifying into components manufacturing for wind energy. One such example is the KGW Schweriner Maschinen und Anlagenbau GmbH in Mecklenburg Vorpommern in the north of Germany, a traditional machine engineering company that was close to insolvency in the early 1990s but successfully diversified into building tubular steel towers for wind energy plants, maintaining 260 manufacturing workplaces in the region to this day (interviewee G5; KGW, 2017).

6.5.4 Key Challenges

Due to the outstanding natural resource and supportive signals from the government some foreign firms have agreed to locate production plants on sites in Britain. A blade facility for offshore turbines in Hull by Siemens is the most cited example. One thousand local jobs have been created through this. Initially there were further expansion plans for this site but due to investment insecurity, mainly caused by the outcome of the referendum on EU membership in 2016 and the resulting lack of clarity on the future trade relationship with other EU countries, these have been put on hold and at the time of writing remain so (Neslen, 2016). The trade relationship with the European Union will crucially impact on

the future of the renewable sector in Britain as it is highly dependent on favourable import conditions for components. This constitutes the main future challenge for the wind energy industry in Britain.

Essletzbichler (2012) assesses that Britain is characterised by relatively strong centralisation and that for the energy system efficiency parameters (energy at the lowest cost) have always been seen as the most important for private producers, grid operators and suppliers with other aims secondary. He points to the importance of unlocking the existing system on its multiple levels (local, regional, national) if there is to be a longer-term sustainable transition. His comparison of the renewable energy industry in Britain, Germany, Spain and Denmark confirms the importance of sub-national policies that complement national strategies. This, however, requires strong, financially well-endowed local and regional governance which he finds to be inconsistent in Britain. Providing the necessary longer term certainty for investment through institutional consistency is also seen as a further key challenge for Britain in the light of the findings from this study.

The regional distribution of energy production and renewable energy in particular remains a problem in Germany where the majority of renewable energy is produced in the north of the country but the majority of the electricity is consumed in the centre and south of the country. As the technology has matured and more, larger turbines are built to capture energy at slower wind speed this regional imbalance has started to shift in the recent years with more new capacity being added in the centre and south of Germany (Deutsche Windguard GmbH, 2015b). Plans to expand the current grid and in particular major electricity lines between the north and south of Germany are being discussed but so far have not been agreed as they face active local and regional opposition (interviewees G3 and G5). A further issue is the balance of the grid in order to match demand where wind plant owners are told to curb the electricity they produce and are financially compensated for doing so ('curtailment'). Electricity storage will offer one solution to this problem. Currently high costs are hindering large scale deployment but the cost of storage solutions is consistently sinking while efficiency is increasing. The expansion of inter-connectors with other countries, known as 'energy union' at European policy level, and thus the export of electricity will further help (Frankfurt School-UNEP Centre, 2016).

A significant challenge to the wind energy industry path in both countries is the rise of manufacturers from China and the USA but the former in particular. China has seen exceptional rates of deployment of wind energy in recent years (Global Wind Energy Council, 2015). There has also been considerable investment in wind energy R&D in China

which is causing concern amongst the German manufacturing industry (Frankfurt School-UNEP Centre, 2016). This threat is even more pressing for the solar industry where EU imports from China have more than doubled between 2006 and 2012 (European Commission, 2014). It remains to be seen for the wind energy industry whether the quality of the currently dominant largely European designs can be matched by these new entrants and at which cost.

Most recently both countries moved towards competitive tender systems. The impact on the industry is not yet known. German industry observers in particular are very concerned about the potential effects of this change. Especially the hitherto existing variety of participants in the renewable energy industry is seen to be under threat.

The section above gave an overview of the current state of the industry and addressed key challenges for the industry. The section below will make explicit the contribution to knowledge by this study.

6.6 CONTRIBUTION TO KNOWLEDGE

This study has combined an eclectic collection of approaches to study the uneven development of an industry across two countries. The unique contribution to knowledge lies in its emphasis on the role of *both* formal and informal institutions on path dependent economic development and in its explicit consideration of the role of and impact on the citizen rather than the firm. Conceptualisations of informal institutions are taken beyond measurable 'social capital' through a strongly qualitative approach. The study argues for a greater consideration of informal institutions in economic geography because of their immediate influence on people's behaviour and their importance in sustainable development. Citizens are recognised in their role for socio-technological transitions as inventors/innovators, agents of diffusion and, crucially, activists who demand institutional change. The conceptual framework offers a perspective of the role of institutions in path dependent economic development as a filter for pathways that seek to reach the wider industrial landscape as well as for changes in the wider environment. Institutions are seen as both constraining and enabling and are argued to be a key influence on agents' perceptions of technological trajectories and changing circumstances. The analysis framework suggests a concrete dynamic between informal institutions and formal institutional arrangements, where informal institutions impact on agents' ability to co-

evolve formal institutions and organisational forms of institutions in response to technological development and changing circumstances. At the same time the rigidity of the formal institutional arrangements determines whether new ideas can get a foothold amongst agents both outside and within organisational forms of institutions.

Both frameworks are transferable, meaning that they can be used not only to study the development of the wind energy industry but any transitional socio-technological development. The definitions of the key concepts are deliberately kept relatively open to allow for the distinct circumstances of potential case studies.

6.7 LIMITATIONS OF THIS STUDY

Whilst the previous section summarised the key contributions to the existing body of knowledge by this thesis this section discusses some of the limitations of this work.

An important limitation is that the case study remained focused on the national level and did not consider inter-regional dynamics which may have yielded further interesting results. This was mostly the case because the experts interviewed as part of the pilot study all emphasised that the most important decisions for the development of the wind energy industry were made at the national level. To some extent it was also due to the necessity to strictly focus down on one aspect because of the time and resource constraints within a PhD study. To further improve our understanding of the development of the wind energy industry it would be interesting to study in detail the socio-economic impact that the rise of the wind energy industry had on individual regions, in particular in the north of Germany and perhaps in Scotland in the United Kingdom. Interviewees expressed interest in participation in such a study and could be approached for relevant data. Both frameworks would benefit from consolidation through further in-depth studies of different cases and application on the subnational level in particular. There is little consideration of the inter-dependency between institutions on different aggregate spatial scales in the frameworks although this has been found to be important in the German context especially. A future version should seek to include this.

Conversations with key agents from incumbent firms on their perceptions on the rise of this new entrant would have added a further layer of information. Unfortunately this was not possible because of the difficulty of identifying the right people to talk to and gaining access to them within the time frame. Within a longer study period such shortcomings could be addressed. Conversations with highly knowledgeable agents from

now large wind energy firms (who are increasingly turning into the new incumbents) provided a good substitute for this study.

There is only limited consideration of the strictly technological development aspect in this study. There does, however, exist plenty of literature on this subject including on the development of wind energy technologies (e.g. Musgrove, 2010; Gipe, 1995; Simmie et al., 2014; Carpenter et al., 2012; Simmie, 2012; Heymann, 1998; Ohlhorst, 2008; European Wind Energy Association, 2009; Szarka & Bluehdorn, 2006; Garud & Karnoe, 2003). In fact one interviewee pointed out that the focus on the role of institutions rather than technology especially raised his interest in participation in this study (interviewee G13).

6.8 FUTURE RESEARCH AVENUES

This section discusses a number of potential future research avenues that could be followed building on the insight from this study.

Both frameworks, the analysis framework in particular, would profit of consolidation through application to different cases. This could be both different geographies and different technologies. For example it could be applied to the study of the development of the solar industry, which developed against the very similar background and context of climate change and the need for an energy transition. The historical development of any industry which is expected to challenge strongly path dependent industrial landscapes can be examined using the frameworks. They are particularly useful to the study of transitional technological development because of their explicit consideration of the role of the civil society as well as institutional settings.

Another future research avenue is the application of the analysis framework to the subnational context. This may be different subnational jurisdictions or strategic planning regions. An example is the divergent development between Italy's north and south, where the explicit consideration of informal institutions could yield interesting results. Different strategic regions in Europe or elsewhere could also be compared. Alternatively the framework may be used to compare the relative role of formal and informal institutions for regional development or to analyse the success or failure of cross boundary collaboration with a focus on the role of institutional settings in European regions.

The conceptual framework is currently strongly rooted in Western European thinking about the role of the civil society and the state and corresponding varieties of

capitalism. A further interesting research avenue is therefore the application of the framework in countries or regions in the global south to challenge inherent preconceptions. A comparison of the diffusion of a transitional (e.g. renewable energy) technology in a region in the global north and in the global south could help to further our understanding of the role of both formal and informal institutions in studies of global development and technological transition. For such research close collaboration with colleagues with in-depth local knowledge and cultural awareness of countries and communities from the global south is important.

The pathways defined in the framework do not necessarily have to be technological. The framework can be used to study the introduction and development of any innovative approach of a transitional nature to a path-dependent system. Informal institutions and factors, for example organisational culture, can have a significant impact on such processes and conflict with formal institutions.

The author would be interested in building on her experience from this study in the described way herself as part of a postdoctoral post or in advising other researchers in doing so.

6.9 IMPLICATIONS FOR ECONOMIC GEOGRAPHY

This section offers thoughts on implications of the findings of this study for the field of economic geography and for society.

An important lesson that has transpired from this study for the economic geography community is that strongly qualitative studies have a lot to contribute to this academic field. Especially in the area of transitional studies towards sustainable development, where everything depends on the behaviour of citizens, it is of great importance to offer explanations based on the in-depth understanding of people's experiences and perceptions. These are accessible only through qualitative research approaches. Quantitative indicators alone do not describe important aspects of transitional change and conventional economic models do not sufficiently explain it. Great potential lies within combined approaches and the collaboration between two researchers, one with a quantitative and one with a qualitative focus. It is also important for the economics profession and for economic policy to open up to alternative, heterodox modes of explanation and description. Much useful work is carried out in this academic niche but it has not achieved main stream status yet.

Furthermore this study makes a contribution to the work of an as of yet relatively marginal group of economic geographers who call for a citizen focus in economic geography. Again, especially in studies of transitional development, much depends on the motivations and perceptions of citizens. It is important to consider their significant potential to socially and technologically innovate, to organise themselves in social movements in order to put pressure on policymakers, and to both diffuse and improve technology by providing user feedback. Economic geographers, those with an explicitly qualitative focus in particular, have a responsibility to give sufficient consideration to the role of the citizen in explaining economic processes, technological transition, and institutional change.

This thesis was influenced by a range of disciplines as the researcher refused to be tied to one tradition long into the course of the study. The result is an eclectic collection of aspects of different schools of thought, a truly inter-disciplinary work. The researcher has visited three main conferences during the writing up period, one on economic geography, one on institutional research and one on evolutionary political economy. The study was relevant to all fields and made a valuable contribution to discussions. 'Cross fertilisation' and 'engaged pluralism' between disciplines and research areas benefit the individual researcher greatly and enrich the wider scientific community. Such approaches should thus be strongly encouraged amongst young researchers.

Finally a wider lesson from the findings of this study for those members of society that are responsible for the shape and constellation of formal institutional arrangements (so to some extent all of us): Stay open to technological developments, make informed decisions about what development is desirable and what is not, and be aware of and flexible toward changing circumstances that may require important changes in established practices! It is important that we continuously evaluate and amend our formal institutional arrangements against our environment so that we do not hinder beneficial socio-technical development and make sure to unleash its socio-economic potential for our society in a responsible way.

6.10 IMPLICATIONS FOR POLICY MAKING

Reasonable knowledge of a country or region's history helps to understand its institutional constellations and the mind sets of its inhabitants. This study has shown that the historical development of a country or region crucially influences the formation of informal as well

as formal institutional arrangements. In the present case of Britain and Germany the outcome of World War II had a great impact on the 'national consciousness' in each country and as a consequence on the shape of their institutions. Whilst Britain remains highly centralised, despite attempts at devolution in some regions, a strong federal structure in Germany ensures greater dispersal of power. Although this is identified as a stumbling block by many Germans, in the case of the development of the wind energy industry it appears that the strength of the local and regional level has provided an important 'opportunity structure' for innovative approaches in policy and technology. Financially well-equipped local authorities were able to support local initiatives that seemed likely to benefit the locality and region on the long term. Formal institutional arrangements should be structured such as to offer protected spaces and 'niches', where both new policy approaches as well as novel technological solutions may be tried.

The state itself should be regarded as a pro-active participant in the innovation process. It is not merely a participant in the very early, explorative stages through innovation funding but it should be allowed to actively support and participate in the development of innovative products and technologies all the way through to industrialisation and diffusion. It should seek to form strong and fair partnerships with the private sector and should be allowed to retrieve funding e.g. through retaining equity. Instead of offering beneficial tax arrangements if they agree to lose the IPR, inventors and innovators should be assisted in testing, developing and industrialising their products with a view to retaining the mid to longer term socio-economic benefits that such an industrialisation may bring to a country or region.

The well-established agreement on the need of an energy transition in Germany led to a stable framework, within which the details could be negotiated amongst agents. The shared sentiment against nuclear power enabled the continuity and stability of policy beyond electoral cycles. This provided crucial security for investors. Policy must be orientated towards the long term rather than towards short term political gain. Agreement on longer term strategic aims provides an important stable framework for investment and longer term planning for all affected agents. Within the agreed goals a variety of technological development strands should be supported, allowing for failure and learning processes. For this an environment should be fostered, which brings together technological path creators with users and consumers and therefore encourages feedback between different agents and different stages of innovation.

This study has shown that novel ideas will often enter the political realm and policy making via informal institutions. Through their direct influence on agents' behaviour, they become access channels for new ideas to get a foothold amongst policymakers. At the same time the degree of rigidity of the formal institutional arrangements determines whether this is possible. Formal institutional arrangements, including policy, must be designed so as to allow for changes amongst the wider society, e.g. shifts in attitudes, to reach the political realm. Policy should be designed to be continuously reviewed in light of potential advances in relevant technologies or important changes of the wider context. An example beyond the present case might be the rapid development of information and communication technology and associated safety and privacy concerns in the context of the perceived global threat of terrorism. Whilst the stability of formal institutional arrangements enables citizens, they must co-evolve with technological development and changing circumstances in order not to become irrelevant or a hindrance and therefore lose their positive, enabling capacity.

Policy makers themselves have a responsibility to stay acquainted with the electorate, to maintain an understanding of the daily lives of citizens. They should seek to understand their concerns but also to hear their ideas. The citizens' innovative potential can only be fully brought to fruition if there are access channels for their ideas and their experience to policy. An example for such an innovative access channel might be a citizen's economic council or similar models where groups of citizens are encouraged to contribute their experience to decision making on national policy. Valuable steps are already being taken but, again, most have not left the experimental stages yet.

Elitism has been found to be a strong influence on decision making over energy policy in Britain. It is paramount that a nation does not allow for one fraction of society to capture organisational forms of institutions and prevent access for others. This can only be avoided if the civil service ensures recruitment from a broad range of social backgrounds and citizens from all backgrounds are encouraged to become not just politically engaged but prepared to represent their constituencies. Such political empowerment must be fostered amongst the children and youth in a country. Citizens must know that they have the power to influence their country's pathways not only at the ballot box but in their everyday lives.

6.11 CONCLUSION

It is argued through this thesis that, whilst the economic and industrial landscape naturally evolves in a path dependent way, institutions have a filtering impact on which new technological pathways reach the industrial landscape. They filter the perceptions of agents of technological trajectories and novel approaches and of changes in the wider environment. Different institutional constellations in different countries or regions are therefore one important cause of divergent development paths.

Furthermore both informal and formal institutions play an important role. Informal institutions directly influence agents' perceptions and therefore shape their ability to co-evolve the formal institutional arrangements in light of new technological path creation or changing circumstances. They can provide important access channels for new ideas and approaches to enter institutional arrangements. At the same time the degree of rigidity of formal institutional arrangements determines agents' ability to demand or implement institutional change or to even perceive the need for such change.

In practice the outright rejection of nuclear power amongst an increasing part of the German population influenced the behaviour of individuals across society. This led to amendments of the legal and regulatory framework in support of development of technologies for energy generation including wind power technology. An additional driver was the increasing recognition of climate change. In contrast there was no comparable strength of sentiment amongst the British population. Instead the capture of political decision making by economic elites prevented similar institutional co-evolution from occurring. Whilst in Germany inventors and entrepreneurs were often emotionally driven to invent and to invest, their British counterparts were either focused primarily on the business opportunity or lacked access to independent funding opportunities. Much of the initial activity in Germany was funded by local or regional banking outlets with a regional development remit or by enthusiastic private individuals with a personal connection to the inventor. Therefore the returns from such investments tended to stay in the region and benefits were seen locally. Citizens in Britain were at best ambiguous about wind energy or actually campaigning against it whilst citizens in Germany attended demonstrations in support of renewable sources of energy and against nuclear power in large numbers. Many also invested in small scale renewable power schemes in their community. Politicians in Germany were moved either by personal motivation or through increasing pressure by the electorate to make changes to the regulatory framework and to support the young wind

energy industry whilst there were no comparable 'champions' for renewable energy in British politics. Finally there is evidence that businesses in Germany changed their practices in response to the increasing recognition of the importance of a transition towards renewable energy amongst the population and the resulting consumer pressure as well as because of generational changes within organisations.

What transpires from this study is that it matters who is the carrier of a transition – who finances and in turn profits of new companies or investments, who directly or indirectly receives the financial support that is handed out by governmental organisations on different levels. Policies which encourage new entrants who challenge incumbents lead to a greater power distribution and thus to more equitable outcomes. When Britain changed the formal institutional framework in favour of better support for renewable energy production, the mechanism did not encourage new entrants but instead benefitted the incumbent agents. They profited from significant support to diversify their electricity production into renewable energy and schemes were developed. The 'power' thus remained in the hands of an existing (energy) establishment and the economic benefits of the transition towards renewable energy largely stayed with incumbent firms and respective suppliers from abroad which led to acceptability problems of wind energy schemes in Britain. This is in contrast to Germany where new entrants and small agents were supported early on and challenged incumbent companies.

The result is a wind sector in Germany that is very varied and dominated by small and medium enterprises, where a number of turbine producers remain, and where most of the socio-economic benefits and profits stay in the region and country. In contrast in Britain no turbine producers have survived, the sector is dominated by large, often foreign ruled companies and the wider socio-economic benefits including major profits tend to escape the region and country.

7 Bibliography

Allmendinger P and Haughton G (2013) The Evolution and Trajectories of English Spatial Governance. *Planning, Practice and Resesarch*. 28 (1), 6–26.

Arthur WB (1989) Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal*. 99 (394), 116–131.

Bathelt H and Glückler J (2012) *Wirtschaftsgeographie*. Stuttgart, GER

Bazeley P and Jackson K (2013) *Qualitative Data Analysis with NVivo* (2nd edition). J. Seaman ed. London, UK: SAGE Publications Ltd

Bhaskar R (1979) *The Possibility of Naturalism - A Philosophical Critique of the Contemporary Human Sciences*. Brighton, UK: The Harvester Press

Blaikie N (2007) *Approaches to social enquiry: advancing knowledge* (2nd edition). Cambridge, UK: Polity

Blaikie N (2000) *Designing Social Research*. Cambridge, UK: Polity Press

de Boer C and Catsburg I (1988) The Impact of Nuclear Accidents on Attitudes Toward Nuclear Energy. *The Public Opinion Quarterly*. 52 (2), 254–261.

Böhler-Bädeker S and Mersmann F (2013) *Ein Ziel, viele Strategien - Klimapolitik in Deutschland*. [Online] Available at: http://www.bpb.de/gesellschaft/umwelt/klimawandel/38554/klimapolitik-in-deutschland (accessed 10/01/17).

Boschma R (2007) *Path Creation, Path Dependence and Regional Development*. J. Simmie & J. Carpenter eds. Oxford: Oxford Brookes University, NESTA

Boschma RA and Frenken K (2007) Introduction: Applications of Evolutionary Economic Geography. In: K. Frenken ed. *Applied evolutionary economics and economic geography*. Cheltenham, UK: Edward Elgar. 326.

Boschma RA and Frenken K (2006) Why is economic geography not an evolutionary science? Towards an evolutionary economic geography. *Journal of Economic Geography*. 6, 273–302.

Boschma R and Frenken K (2009) Some notes on institutions in economic geography. *Economic Geography*. 85 (2), 151–158.

Boschma R and Frenken K (2011) Technological relatedness, related variety and economic geography. In: P. Cooke, B. Asheim, R. Boschma, R. Martin, D. Schwartz, & F. Tödtling eds. *The Handbook of Regional Innovation and Growth*. Cheltenham, UK: Edward

Elgar. 187–197.

Boschma R and Martin R (2010) The aims and scope of evolutionary economic geography. In: R. Boschma & R. Martin eds. *The Handbook of Evolutionary Economic Geography*. Cheltenham, UK: Edward Elgar. 3–39.

Bristow G and Healy A (2014) Regional Resilience: An Agency Perspective. *Regional Studies*. 48 (5), 923–935.

Bryman A (2001) *Social Research Methods*. Oxford, UK: Oxford University Press

Buckley W (1998) *Society - A Complex Adaptive System*. Amsterdam, NL: Gordon and Breach Publishers

Bundesverband Windenergie (2015a) *Akteursstrukturen von Windenergieprojekten in Deutschland*. Berlin, Germany

Bundesverband Windenergie (2015b) *Jahrbuch Windenergie*. F. Eggert, E. Kommunikation, A. Bittelmeyer, & S. Rentzing eds. Berlin, Germany: Bundesverband Windenergie

Burnham P, Gilland K, Grant W and Layton-Heny Z (2004) *Research Methods in Politics*. B. G. Peters, J. Pierre, & G. Stoker eds. Basingstoke, UK: palgrave macmillan

Campaign for Nuclear Disarmament (2016) *The History of CND*. [Online] Available at: http://www.cnduk.org/about/history (accessed 18/07/16).

Carpenter J, Simmie J, Conti E, Povinelli F and Kipshagen JM (2012) Innovation and New Path Creation: the Role of Niche Environments in the Development of the Wind Power Industry in Germany and the UK. *European Spatial Research and Policy*. 19 (2), 87–101.

Chang H-J (2002) Breaking the Mould: An Institutionalist Political Economy Alternative to the Neoliberal Theory of the Market and the State. *Cambridge Journal of Economics*. 26 (5), 539–559.

Chapman K and Walker DF (1990) *Industrial Location - Principles and Policies* (2nd edition). Oxford, UK: Basil Blackwell

Childs D (2001) *Britain since 1945* (5th edition). London, UK: Routledge

Committee on Climate Change (2017) *Committee on Climate Change*. [Online] Available at: https://www.theccc.org.uk/ (accessed 09/01/17).

Cooke P (2012a) *Complex Adaptive Innovation Systems: Relatedness and Transversality in the Evolving Region (Regions and Cities)*. London, UK: Routledge

Cooke P (2011) Green Innovation. In: P. Cooke, B. Asheim, R. Boschma, R. Martin, D. Schwartz, & F. Tödtling eds. *The Handbook of Regional Innovation and Growth*. Cheltenham, UK: Edward Elgar. 434–446.

Cooke P (2012b) Transversality and Transition : Green Innovation and New Regional Path Creation. *European Planning Studies*. 20 (5), 817–834.

Corbetta G (2014) *The European offshore wind industry - key trends and statistics 2013*. Brussels, BEL

Cortinovis N, Xiao J, Boschma R and Van Oort F (2016) Quality of government and social capital as drivers of regional diversification in Europe. *Papers in Evolutionary Economic Geography*. (#16.10).

Cox E, Johnstone P and Stirling A (2016) *SPRU Working Paper Series 2016-16: Understanding the Intensity of UK Policy Commitments to Nuclear Power*

Creswell JA (2014) *Research Design - Qualitative, Quantitative and Mixed Methods Approaches* (4th edition). London, UK: SAGE Publications Inc.

Crouch C (2005) *Capitalist Diversity and Change*. Oxford, UK: Oxford University Press

Crouch C, Schröder M and Voelzkow H (2009) Regional and sectoral varieties of capitalism. *Economy and Society*. 38 (4), 654–678.

Crouch C and Voelzkow H (2009) Introduction: Local and Sectoral Diversity Within National Economic Systems. In: C. Crouch & H. Voelzkow eds. *Innovation in Local Economies - Germany in Comparative Context*. Oxford, UK: Oxford University Press. 1–21.

Cullingworth B, Nadin V, Hart T, Davoudi S, Pendlebury J, Vigar G, Webb D and Townshend T (2015) *Town and Country Planning in the UK* (15th edition). Abingdon, UK: Routledge

David PA (1985) Clio and the Economics of QWERTY. *The American Economic Review*. 75 (2), 332–337.

Dawley S (2013) Creating New Paths? Offshore Wind, Policy Activism, and Peripheral Region Development. *Economic Geography*. 90 (1), 91–112.

Dawley S, Mackinnon D, Cumbers A and Pike A (2015) Policy activism and regional path creation : the promotion of offshore wind in North East England and Scotland. *Cambridge Journal of Regions, Economy and Society*. 8 (2), 257–272.

DECC (2015) Installed capacity [MW] by regions. Available at: https://www.gov.uk/government/statistics/regional-renewable-statistics.

Department of Trade and Industry (2003) *Energy White Paper - Our energy future - Creating a low carbon economy*. London, UK

Department of Trade and Industry (2007) *Meeting the Energy Challenge A White Paper on Energy*. London, UK

Department of Trade and Industry (2006) *The Energy Challenge*. London, UK

Deutsche Windguard GmbH (2015a) Installierte Windenergieleistung in Deutschland. Available at: https://www.wind-energie.de/infocenter/statistiken/deutschland/installierte-windenergieleistung-deutschland.

Deutsche Windguard GmbH (2015b) *Status of land-based wind energy development in Germany*. Varel, Germany

Deutscher Bundestag (2000) Gesetz für den Vorrang Erneuerbarer Energien.

Deutscher Bundestag (1990) Gesetz über die Einspeisung von Strom aus erneuerbaren Energien in das öffentliche Netz (Stromeinspeisungsgesetz).

Dictionary.com (2013) *Technology*. [Online] Available at: http://dictionary.reference.com/browse/technology.

Die Zeit (1993) Wer kritisch fragt ist noch längst kein Kernkraftgegner. *Die Zeit*. Available at: http://nixatom.de/images/EE4.jpg.

Dillig M, Jung M and Karl J (2015) The impact of renewables on electricity prices in Germany - An estimation based on historic spot prices in the years 2011 - 2013. *Renewable and Sustainable Energy Reviews*. (57), 7–15.

Doblinger C and Soppe B (2013) Change-actors in the U.S. electric energy system: The role of environmental groups in utility adoption and diffusion of wind power. *Energy Policy*. 61, 274–284.

Dosi G (1982) Technological paradigms and technological trajectories. *Research Policy*. 11, 147–162.

Eisenbeiß G (2014) Meine Geschichte zur Entwicklung der Windenergie. Available at: http://www.politikessays.de/EnergieKlima.

Eisenbeiß G (2012) Neue Technologien erfordern eine neue Förderpolitik: das Beispiel

Windkraft. *Gaia*. 21 (4), 288–289.

Elliott D (1978) *The politics of nuclear power*. London, UK: Pluto Press

Epstein M (2012) Introduction to the philosophy of science. In: C. Seale ed. *Researching Society and Culture*. London, UK: SAGE Publications Ltd. 7–28.

Essletzbichler J (2012) Renewable Energy Technology and Path Creation: A Multi-scalar Approach to Energy Transition in the UK. *European Planning Studies*. 20, 791–816.

European Commission (2014) *Energy Economic Developments in Europe*. Brussels, BEL

European Parliament and the Council of the European Union (2001) DIRECTIVE 2001/77/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.

European Wind Energy Association (2012) *Green Growth*. Brussels, BEL

European Wind Energy Association (2009) *Wind Energy - The Facts. A guide to the technology, economics and future of wind power*. London, UK: Earthscan

European Wind Energy Association (2016) *Wind in power - 2015 European statistics*. Brussels, BEL

eurostat (2016a) Electricity prices components for domestic consumers - annual data. Available at: http://ec.europa.eu/eurostat/web/products-datasets/-/ten00117.

eurostat (2016b) Foreign ownership of domestic inventions in patent applications to the EPO by priority year. Available at: http://ec.europa.eu/eurostat/web/products-datasets/-/pat_ep_nfgn.

eurostat (2016c) Main components of current account balance [% of GDP; 2014]. Available at: http://ec.europa.eu/eurostat/statistics-explained/images/9/90/Main_components_of_the_current_account_balance%2C_2014_(%25_of_GDP)_YB15.png.

eurostat (2016d) Share of energy from renewable sources. Available at: http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_ind_335a.

eurostat (2016e) Supply, transformation and consumption of renewable energies - annual data. Available at: http://ec.europa.eu/eurostat/web/products-datasets/-/nrg_107a.

EVS (2015) European Values Study Longitudinal Data File 1981-2008 (EVS 1981-2008). ZA4804 Data file Version 3.0.0. Available at:

https://dbk.gesis.org/dbksearch/sdesc2.asp?no=4804&db=e&doi=10.4232/1.12253.

Frankfurt School-UNEP Centre (2016) *Global Trends in Renewable Energy Investment 2016*. Frankfurt, GER

Freeman C and Perez C (2008) Structural crises of adjustment, business cycles and investment behaviour. In: *Systems of Innovation*. Cheltenham, UK: Edward Elgar. 38–73.

Freeman C and Soete L (1997) *The Economics of Industrial Innovation* (3rd edition). London, UK: Pinter

Frenken K, Van Oort F and Verburg T (2007) Related Variety, Unrelated Variety and Regional Economic Growth. *Regional Studies*. 41 (5), 685–697.

Garrad A (2012) The lessons learned from the development of the wind energy industry that might be applied to marine industry renewables. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*. 370 (1959), 451–471.

Garud R, Hardy C and Maguire S (2007) Institutional Entrepreneurship as Embedded Agency : An Introduction to the Special Issue. *Organization Studies*. 28 (7), 957–969.

Garud R and Karnoe P (2003) Bricolage vs. breakthrough: distributed and embedded ageny in technology entrepreneurship. *Research Policy*. 32 (2), 277–300.

Garud R and Karnoe P (2001) Path Creation as a Process of Mindful Deviation. In: R. Garud & P. Karnoe eds. *Path Dependence and Creation*. London, UK. 1–40.

Geels FW (2002) Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*. 31, 1257–1274.

Geels FW, Kern F, Fuchs G, Hinderer N, Kungl G, Neukirch M and Wassermann S (2014) Unleashing new entrants versus working with incumbents : A comparative multi-level analysis of the ongoing German and UK low-carbon electricity transitions (1990-2013). *Paper Presented at the Workshop on Incumbent-challenger Interactions in Energy Transitions. University of Stuttgart.*. (November).

Gertler MS (2005) Tacit Knowledge, Path Dependency and Local Trajectories of Growth. In: C. Antonelli & B. Carlsson eds. *Rethinking Regional Innovation and Change: Path Dependency or Regional Breakthrough*. New York, USA: Springer. 23–41.

Giddens A (1979) *Central Problems in Social Theory - Action, Structure and Contradition in Social Analysis*. London, UK: The Macmillan Press Ltd

Giddens A (1974) Elites in the British class structure. In: P. Stanworth & A. Giddens eds.

Elites and Power in British Society. Cambridge, UK: Cambridge University Press.

Giddens A (1984) *The Constitution of Society*. Cambridge, UK: Polity Press

Gipe P (1995) *Wind Energy - Comes of Age*. Toronto, Canada: John Willey & Sons, Inc.

Glaeser E, Kallal H, Scheinkman J and Shleifer A (1991) Growth in Cities. *National Bureau of Economic Research Working Papers*. (July).

Glaessner G-J (2005) *German Democracy - From Post World War II to the present day*. Oxford, UK: Berg

Global Wind Energy Council (2015) *Global Wind Report - Annual Market Update*. Brussels, BEL

Grabher G (1993) The weakness of strong ties: the lock-in of regional develoment in the Ruhr area. *The embedded firm: On the socioeconomics of industrial networks*, 255–277.

Groenewegen J, Spithoven A and Van den Berg A (2010) *Institutional Economics - An introduction*. London, UK: palgrave macmillan

Hakim C (2000) *Research Design - Successful designs for social and economic research* (2nd edition). London, UK: Routledge

Hall PA and Soskice D (2001) An Introduction to Varieties of Capitalism. In: P. A. Hall & D. Soskice eds. *Varieties of Capitalism*. Oxford, UK: Oxford University Press. 1–68.

Hall S, Foxon TJ and Bolton R (2016) Financing the civic energy sector: How financial institutions affect ownership models in Germany and the United Kingdom. *Energy Research and Social Science*. 12, 5–15.

Hassink R, Klaerding C and Marques P (2014) Advancing Evolutionary Economic Geography by Engaged Pluralism. *Regional Studies*. 48 (7), 1295–1307.

Heymann M (1998) Signs of Hubris: The Shaping of Wind Technology Styles in Germany, Denmark, and the United States, 1940 - 1990. *Technology and Culture*. 39 (4), 641–670.

HM Government (2008) Energy Act.

Hodgson GM (2000) What is the essence of institutional economics. *Journal of Economic Issues*. 34 (2), 317–329.

House of Commons - Environmental Audit Committee (2006) *Keeping the lights on: Nuclear, Renewables and Climate Change*. London, UK

IPCC (2017) *IPCC - Organization*. [Online] Available at:

http://www.ipcc.ch/organization/organization.shtml (accessed 09/01/17).

IRENA (2016) DTU Global Wind Atlas - Average wind speed at 200m height - 1km resolution. Available at: http://irena.masdar.ac.ae/.

ISSP Research Group (2012) International Social Survey Programme: Environment III - ISSP 2010, ZA5500 Data file Version 2.0.0. Available at: http://zacat.gesis.org/webview/index.jsp?object=http://zacat.gesis.org/obj/fStudy/ZA5500.

ISSP Research Group (1986) International Social Survey Programme: Role of Government I - ISSP 1985, ZA1490 Data file Version 1.0.0. Available at: http://zacat.gesis.org/webview/index.jsp?object=http://zacat.gesis.org/obj/fStudy/ZA1490.

ISSP Research Group (1992) International Social Survey Programme: Role of Government II - ISSP 1990, ZA1950 Data file Version 1.0.0. Available at: http://zacat.gesis.org/webview/index.jsp?object=http://zacat.gesis.org/obj/fStudy/ZA1950.

ISSP Research Group (1999) International Social Survey Programme: Role of Government III - ISSP 1996, ZA2900 Data file Version 1.0.0. Available at: http://zacat.gesis.org/webview/index.jsp?object=http://zacat.gesis.org/obj/fStudy/ZA2900.

ISSP Research Group (2008) International Social Survey Programme: Role of Government IV - ISSP 2006, ZA4700 Data file Version 1.0.0. Available at: http://zacat.gesis.org/webview/index.jsp?object=http://zacat.gesis.org/obj/fStudy/ZA4700.

Jackson G (2010) Actors and institutions. In: G. Morgan, J. L. Campbell, C. Crouch, O. K. Pederson, & R. Whitley eds. *The Oxford Handbook of Comparative Institutional Analysis*. Oxford, UK: Oxford University Press. 63–86.

Jacobs J (1970) *The economy of cities*. London, UK: Cape

Jacobsson S and Lauber V (2006) The politics and policy of energy system transformation—explaining the German diffusion of renewable energy technology. *Energy Policy*. 34 (3), 256–276.

Jones O (2014) *The Establishment: and how they get away with it*. London, UK: Allen Lane

Kemp R (1994) Technology and the Transition to Environmental Sustainability - The

problem of technological regime shifts. *Futures*. 26 (10), 1023–1046.

Kemp R, Schot J and Hoogma R (1998) Regime shifts to sustainability through processes of niche formation: The approach of strategic niche management. *Technology Analysis & Strategic Management*. 10 (2), 175–198.

KGW (2017) *KGW Schweriner Maschinen- und Anlagenbau GmbH*. [Online] Available at: http://www.kgw-schwerin.de/en/home/ (accessed 13/04/17).

Kline SJ and Rosenberg N (1986) An overview of innovation. In: R. Landau & N. Rosenberg eds. *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington D.C., USA: National Academy Press. 275–305.

Kriener M (2016) Rudolf Bahro brachte Erdbeeren. *taz. zeozwei*, 8–12.

Kuhn T (1962) *The Structure of Scientific Revolutions*. Chicago, IL, USA: University of Chicago Press

Lamers G, Jansen B, Marcinczyk A, Stephan B, Plewa C, Albrecht M, Tack A and Gutsche J-M (2011) *Kreis Nordfriesland - Gemeinsam den Wandel gestalten. Masterplan Daseinsvorsorge.* Husum, Germany

Lauber V (2012) Wind Power Policy in Germany and the UK: Different Choices Leading to Divergent Outcomes. In: J. Szarka, R. Cowell, G. Ellis, P. A. Strachan, & C. Warren eds. *Learning from Wind Power. Governance, Societal and Policy Perspectives on Sustainable Energy*. Basingstoke, UK: palgrave macmillan. 38–60.

Lehr U, Ulrich P, Lutz C, Thobe I, O'Sullivan M, Simon S, Naegler T, Pfenning U, Peter F, Sakowski F and Bickel P (2015) *Beschäftigung durch erneuerbare Energien in Deutschland : Ausbau und Betrieb, heute und morgen*. Osnabrueck, Berlin, GER

Lissack M (2013) *Pragmatic Constructivism*. [Online] Available at: http://www.modesofexplanation.org/index19.html (accessed 09/12/16).

Lundvall B-Å (1995) Introduction. In: B.-Å. Lundvall ed. *National Systems of Innovation*. London, UK: Pinter. 1–19.

Martin R (2008) Institutional Approaches in Economic Geography. In: E. Sheppard & T. J. Barnes eds. *A Companion to Economic Geography*. Oxford, UK: Blackwell Publishing Ltd. 77–94.

Martin R (2011) Regional economies as path-dependent systems: some issues and implications. In: P. Cooke, B. Asheim, R. Boschma, R. Martin, D. Schwartz, & F.

Tödtling eds. *The Handbook of Regional Innovation and Growth*. Cheltenham, UK: Edward Elgar. 198–210.

Martin R and Sunley P (2006) Path dependence and regional economic evolution. *Journal of Economic Geography*. 6, 395–437.

Martin R and Sunley P (2015) Towards a Developmental Turn in Evolutionary Economic Geography? *Regional Studies*. 49 (5), 712–732.

Marx K (1954) *The eighteenth Brumaire of Louis Bonaparte, 3rd rev. ed.* Moscow: Progress

Mitchell C (2008) *The Political Economy of Sustainable Energy*. Basingstoke, UK: palgrave macmillan

Musgrove P (2010) *Wind Power*. Cambridge, UK: Cambridge University Press

National Audit Office (2016) *Nuclear power in the UK*. London, UK

Nelson RR (2002) Bringing institutions into evolutionary growth theory. *Journal of Evolutionary Economics*. 12, 17–28.

Nelson RR (1998) The Co-evolution of Technology, Industrial Structure, and Supporting Institutions. In: G. Dosi, D. Teece, & J. Chytry eds. *Technology, Organisation and Competitiveness - Perspectives on Industrial and Corporate Change*. Oxford, UK: Oxford University Press. 319–335.

Nelson RR and Winter SG (1982) *An Evolutionary Theory of Economic Change*. Cambridge, USA: The Belknap Press of Harvard University Press

Nelson RR and Winter SG (1977) In Search of Useful Theory of Innovation. *Research Policy*. 6, 36–76.

Neslen A (2016) Siemens freezes new UK wind power investment following Brexit vote. *The Guardian Online*. Available at: https://www.theguardian.com/environment/2016/jun/28/siemens-freezes-new-uk-wind-power-investment-following-brexit-vote.

North DC (1991) Institutions. *Journal of Economic Perspectives*. 5 (1), 97–112.

North DC (1996) *Institutions, Institutional Change and Economic Performance*. Cambridge, UK: Cambridge University Press

O'Sullivan M, Edler D, Bickel P, Lehr U, Peter F and Sakowski F (2014) *Bruttobeschäftigung durch erneuerbare Energien in Deutschland im Jahr 2013*. Berlin, Germany

OECD (2013) REGPAT database, July. Available at: www.oecd.org/sti/ipr-statistics.

OECD (1996) *The knowledge-based economy*. Paris

Oelker J (2005) *Windgesichter*. Dresden, GER: Sonnenbuch Verlag

Ohlhorst D (2008) *Windenergie in Deutschland - Konstellationen, Dynamiken und Regulierungspotenziale im Innovationsprozess*. Berlin, Germany: VS Research

Perez C (1983) Structural Change and Assimilation of New Technologies in the Economic and Social Systems. *Futures*. 15 (5), 357–375.

Perez C (2009) Technological revolutions and techno-economic paradigms. *Cambridge Journal of Economics*. 34 (1), 185–202.

Pierrot M (2016) *The Wind Power - Wind Energy Market Intelligence*. [Online] Available at: http://www.thewindpower.net.

Polanyi K, Arensberg CM and Pearson HW eds. (1957) *Trade and Market in the Early Empires - Economies in History and Theory*. Glencoe, IL, USA: The Free Press & The Falcon's Wing Press

Poortinga W, Pidgeon NF, Capstick S and Aoyagi M (2014) *Public attitudes to nuclear power and climate change in Britain two years after the Fukushima accident - Synthesis Report*. London, UK

Porter D (2014) *Electricity Supply, The British Experiment - The intentions were good*. Cirencester, UK: Mereo Books

PricewaterhouseCoopers LLP (2014) *Low Carbon Economy Index 2014*. London, UK Available at: www.pwc.co.uk/sustainability-climate-change.

Puffert D (2001) Path dependence, network form and technological change. *Paper presented at the Conference to Honour Paul David - History matters: Economic Growth, Technology, and Population*.

Rafiqui PS (2009) Evolving economic landscapes: why new institutional economics matters for economic geography. *Journal of Economic Geography*. 9, 329–353.

Rafiqui PS (2010) Varieties of capitalism and local outcomes: A Swedish case study. *European Urban and Regional Studies*. 17 (3), 309–329.

Rave K and Richter B (2008) *Im Aufwind - Schleswig-Holsteins Beitrag zur Entwicklung der Windenergie*. Neumünster, GER: Wachholtz Verlag

RenewableUK (2015a) *Onshore Wind: Economic Impacts in 2014*. London, UK

RenewableUK (2012) *Onshore Wind - Direct & Wider Economic Impacts*. London, UK

RenewableUK (2013) *Wind Energy in the UK - State of the Industry Report*. London, UK

RenewableUK (2015b) *Wind Energy in the UK - State of the Industry Report*. London, UK

Rip A and Kemp R (1998) Technological Change. In: S. Rayner & E. Malone eds. *Human Choice and Climate Change*. Columbus, OH, USA: Batelle Press. 328–372.

Rosenkranz G (2016) Atomkraft - War es das jetzt? *taz. zeozwei*, 36–39.

Sayer A (2000) *Realism and Social Science*. London, UK: SAGE Publications Ltd

Schmidt MG (2003) *Political Institutions in the Federal Republic of Germany*. Oxford, UK: Oxford University Press

Schumpeter JA (1959) *Capitalism, Socialism and Democracy* (8th edition). London, UK: Ruskin House - George Allen & Unwin Ltd

Schumpeter JA (1983) *The Theory of Economic Development - An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Harvard, USA: Transaction Books

Scott AJ and Storper M (1987) High technology industry and regional development: a theoretical critique and reconstruction. *International Social Science Journal*. 39 (112), 215–232.

Setterfield M (1993) A Model of Institutional Hysteresis. *Journal of Economic Issues*. 27 (3), 755–774.

Simmie J (2012) Path Dependence and New Technological Path Creation in the Danish Wind Power Industry. *European Planning Studies*. 20 (5), 753–772.

Simmie J, Sternberg R and Carpenter J (2014) New technological path creation: Evidence from the British and German wind energy industries. *Journal of Evolutionary Economics*.

Sine WD and Lee BH (2009) Tilting at Windmills? The Environmental Movement and the Emergence of the U.S. Wind Energy Sector. *Administrative Science Quarterly*. 54, 123–155.

Smith M (2003) *Social science in question* (3rd edition). London, UK: SAGE Publications Ltd

Spiegel (2014) Plan der Energie-Konzerne: Bund soll Abriss von Atom-Meilern finanzieren. *Spiegel Online*. Available at: http://www.spiegel.de/wirtschaft/unternehmen/atomkraftwerke-energiekonzerne-fordern-bad-bank- vom-bund-a-968719.html.

Sterman JD and Wittenberg J (1999) Path dependence, competition, and succession in the dynamics of scientific revolution. *Organization Science*. 10 (3), 322–341.

Stern N (2007) *The Economics of Climate Change - The Stern Review*. Cambridge, UK: Cambridge University Press

Strambach S (2010) Path dependence and path plasticity: the co-evolution of institutions and innovation - the German customized business software industry. In: R. Boschma & R. Martin eds. *The Handbook of Evolutionary Economic Geography*. Cheltenham, UK: Edward Elgar. 406–429.

Szarka J (2007) *Wind Power in Europe - Politics, Business and Society*. Basingstoke, UK: palgrave macmillan

Szarka J and Blühdorn I (2006) *Wind Power in Britain and Germany: Explaining contrasting development paths*. London, UK

Taylor A (1996) The Politics of Energy Policy in the United Kingdom. *Politics*. 16 (3), 133–141.

Taylor S (2016) *The Fall and Rise of Nuclear Power in Britain*. Cambridge, UK: UIT Cambridge

Teddlie C and Tashakkori A (2009) *Foundations of Mixed Methods Research*. Thousand Oaks, CA, USA: SAGE Publications Inc.

Thatcher M (1988) *Speech to the Royal Society*. [Online] Available at: http://www.margaretthatcher.org/document/107346 (accessed 30/11/16).

Thebanks.eu (2016) *Country Profiles*. [Online] Available at: https://thebanks.eu/countries (accessed 16/06/16).

Thelen K (2010) Beyond comparative statics: Historical institutional approaches to stability and change in he political economy of labour. In: G. Morgan, J. L. Campbell, C. Crouch, O. K. Pederson, & R. Whitley eds. *The Oxford Handbook of Comparative Institutional Analysis*. Oxford, UK: Oxford University Press. 41–61.

Thelen K (2009) Institutional change in advanced political economies. *British Journal of Industrial Relations*. 47 (3), 471–498.

UNFCCC secretariat (2014) *United Nations Framework Convention on Climate Change*. [Online] Available at: http://unfccc.int/2860.php (accessed 09/01/17).

United Nations (1998) Kyoto Protocol To the United Nations Framework. Available at: http://unfccc.int/resource/docs/convkp/kpeng.pdf.

Vasi IB (2011) *Winds of Change: The Environmental Movement and the Global Development of the Wind Energy Industry*. Oxford University Press

Vergne J-P and Durand R (2010) The Missing Link Between the Theory and Empirics of Path Dependence: Conceptual Clarification, Testability Issue, and Methodological Implications. *Journal of Management Studies*. 47 (4), 736–759.

Whitley R (1974) The City and Industry: the directors of large companies, their characteristics and connections. In: P. Stanworth & A. Giddens eds. *Elites and Power in British Society*. Cambridge, UK: Cambridge University Press.

Wijen F and Ansari S (2007) Overcoming Inaction through Collective Institutional Entrepreneurship: Insights from Regime Theory. *Organization Studies*. 28 (7), 1079–1100.

Wilson GA (2012) *Community Resilience and Environmental Transitions*. Abingdon, UK: Routledge

Wind Europe (2016) *Wind in power - 2016 European statistics*. Brussels, BEL

Wood S (2001) Business, Government, and Patterns of Labor Market Policy in Britain and the Federal Republic of Germany. In: P. A. Hall & D. Soskice eds. *Varieties of Capitalism*. Oxford, UK: Oxford University Press. 247–274.

World Commission on Environment and Development (1987) *Our Common Future* (13th, 1991 edition). Oxford, UK: Oxford University Press

8 Appendix

8.1 INVITATION LETTER TO INTERVIEW

Dear Mr/Mrs X,

My name is Camilla Chlebna. I am originally Austrian and study for a PHD at Oxford Brookes University. I am comparing the historical development of the wind energy industry in Britain and Germany. Specifically I am interested in the co-evolution of institutions with the technological development, and which interest groups have influenced the institutional arrangements over the years, how successful they were and why.

I am looking for interviewees who have a good overview of the development of the industry (mostly of course in their own country). I am hoping to speak to a variety of people across the spectrum of civil society agents, representatives of the institutions and of the industry.

Would you be prepared to help me with an expert interview? I would like to do all interviews face-to-face. The length of an interview depends mostly on the interviewee but it should not take more than an hour.

Please let me know where you are based and what would be a good time for you. I am looking forward to hearing from you.

Kind regards,

Camilla M. Chlebna MSc
PhD Student
Oxford Brookes University
Oxford, UK

8.2 PARTICIPANT INFORMATION SHEET

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

The role of institutions in the path-dependent development of the wind energy industry in the United Kingdom and Germany

Principal Researchers:

Prof. Dr. James Simmie, Emeritus Professor of Innovation Studies, Department of Planning, Faculty of Technology, Design and Environment, Oxford Brookes University, jsimmie@brookes.ac.uk

Camilla Chlebna MSc, PHD Student, Department of Planning, Faculty of Technology, Design and Environment, Oxford Brookes University, 12112222@brookes.ac.uk

Dr Dave Valler, Reader in Spatial Planning, Department of Planning, Faculty of Technology, Design and Environment, Oxford Brookes University, dvaller@brookes.ac.uk

What is the purpose of the study?

The background of this study is the divergent development of the wind energy industry in Germany and the United Kingdom. Whilst there are 14 manufacturers of large scale wind turbines in Germany there is not a single one in the United Kingdom. Recently the UK has been catching up with other European countries through rapid deployment of offshore wind farms. These, however, are almost exclusively built by German companies.

The study investigates the role that institutions play as supporters or as barriers to technological development. It also investigates what capacity community energy initiatives have to promote institutional change. The particular focus is on which interest groups have taken influence on policymaking over the years, how successful they were, and why.

The fieldwork will run until autumn 2015. Information will be collected from around 30 respondents in Germany and the United Kingdom. The data will be analysed in winter 2015. Final results will be a PhD thesis and a summary report for participants. There is also the possibility that the finding will be published in relevant journals.

Why have I been invited to participate?

You have been chosen to participate because of your knowledge of one of the aspects of this research. You have been identified as an expert on the development of the wind energy industry through previous academic research or professional knowledge. As I study the interaction of technological development and institutional change your experience is particularly valuable to me.

Do I have to take part?

It is up to you to decide whether or not to take part, as participation is completely voluntary. If you do decide to be involved you will already have this information sheet to keep and be asked to sign a consent form. If you decide to take part you are still free to withdraw at any time, and to withdraw any unprocessed data previously supplied without giving a reason.

What will happen to me if I take part?

An interview, in person, on the phone or via Skype, will be conducted. The information sought is not anticipated to be of a sensitive nature. You will be asked about your experiences, perceptions and opinion related to role of institutions in the development of the wind energy industry. The interview will last approximately 1 hour. During the interview, a voice-recording will be taken with your permission. Otherwise, authorised notes will be taken. The interviews will either take place at your place of work or at a public place. If conducted at your place of work I kindly ask you to seek permission for the interview from your supervisors at your organisation if it is necessary.

What are the possible benefits of taking part?

I hope that the conversation will give you an opportunity to reflect on the development of the wind energy industry and the role that institutions have played in this. The study will inform policymakers on which are the main barriers to technological innovation and it will empower civil agents in developing effective strategies to overcome such barriers.

Will what I say in this study be kept confidential?

All information collected will be kept strictly confidential (subject to legal limitations). Confidentiality, privacy and anonymity will be ensured in the collection, storage and publication of research material. Data generated by the study will be retained in accordance with the University's policy on Academic Integrity and kept securely in electronic form for a period of ten years after the completion of this research project.

What should I do if I want to take part?

Please take time to read the participant information sheet carefully and decide whether to take part in this research. If you decide that you would like to take part in this study, please send a reply to 12112222@brookes.ac.uk

If I haven't heard back from you I may follow up my email with a phone call. If this is unsuccessful I will not make any further attempts.

What will happen to the results of the research study?

The research will be submitted to Oxford Brookes University, and graded as part of a requirement for completion of a Doctor of Philosophy (PhD) degree. Interviewees may have access to a summarized version of the findings upon their request. Anonymity of participants will be ensured in the publication of research material in any form but as the sample size is small some implications for privacy/anonymity might occur. The data generated in the course of the research will be retained in accordance with the University's policy of Academic Integrity and must be kept securely in paper or electronic form for a period of ten years after the completion of a research project. Participants should be aware that there are legal limitations on data confidentiality.

Who is organising and funding the research?

The research is being organised and undertaken by Camilla Chlebna MSc, a PhD research student in the department of Planning under Prof Dr James Simmie as the Director of Studies and Dr Dave Valler as second supervisor, in the Faculty of Technology, Design and Environment at Oxford Brookes University, UK. The PHD project is funded by Oxford Brookes University. The fieldwork is supported by a project grant by Santander Bank.

Who has reviewed the study?

This research has been approved by the University Research Ethics Committee, Oxford Brookes University. If you have any concerns about the way in which the study has been

conducted, you should contact the Chair of the University Research Ethics Committee on ethics@brookes.ac.uk.

Contact for Further Information

For further information you can contact Camilla Chlebna at 12112222@brookes.ac.uk

Thank you for taking the time to read this information sheet.

Camilla Chlebna, June 2015

8.3 CONSENT FORM

The role of institutions in the path-dependent development of the wind energy industry in Germany and the United Kingdom

Camilla Chlebna, PHD Student
AB 2.01, Oxford Brookes University
Gipsy Lane Campus, Headington
Oxford OX3 0BP

Please initial box

1. I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason. ☐

3. I agree to take part in the above study. ☐

	Yes	No
4. I agree to the interview being audio recorded	☐	☐
5. I agree to the use of anonymised quotes in publications	☐	☐
6. I agree that my data gathered in this study may be stored (after it has been anonymised) in a specialist data centre and may be used for future research.	☐	☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature

8.4 QUESTIONNAIRE PILOT STUDY

Name: **Date:**

Place: **Recording: Yes/No**

The overarching question to my research is why the wind energy industry developed earlier and to a greater extent in Germany than in the United Kingdom. My focus is the role of institutions for the development of innovative technologies into a path dependent economic landscape. I use a very broad definition of institutions:

- Formal institutions are the legal frameworks and technical as well as financial infrastructure
- Organisational forms of institutions refers to governments on local, regional, and national level, as well as non- or quasi-governmental organisations and industry lobbying bodies
- Informal institutions include the cultural norms, values, and attitudes amongst the civil society.

An additional interest is the role of bottom up initiatives in the promotion of institutional change.

INTRO

1. What is your own relationship to wind energy and renewable energy technologies in general?

PRECONDITIONS

2. Let me take you back to the initial conditions in which new wind energy technologies were being developed.
3. In the early years which institutions helped or hindered the invention of new wind technologies?
4. What institutional barriers did inventors face in the introduction of new wind technologies?

PATH CREATION

5. How did institutions respond to innovation in new wind technologies?
6. How did government institutions respond to innovation in new wind technologies?
7. Did they respond before or after the introduction of these technologies and if after, how long did this take?
8. What were the main similarities and differences between institutional responses in Britain and Germany? Please can you give some empirical examples?

PATH DEVELOPMENT

9. What legal, financial or technical institutional arrangements were barriers to the development of new wind technologies?
10. What legal, financial or technical institutional arrangements facilitated the development of new wind technologies?
11. Did cultural norms and traditional values play a role for the technological development? How?

12. Were there any significant institutional differences between different regions at any stage of the development of new wind technologies?

OUTCOMES

13. Were there any institutions that were established in response to the diffusion of new wind technologies? Did they help or hinder the diffusion of new wind technologies?
14. Can you think of legal, technical or financial frameworks that have been changed in response to the development of the wind energy technology? How do these in turn affect technology development now?
15. What do you think were the key similarities and differences between Britain and Germany in response to the diffusion of new wind technologies?

COMMUNITY ENERGY

16. Overall, in the development of the wind energy industry do you feel that community based initiatives and social movements like the 'green movement' played a role? How did they influence the development? At what stage in the technological development was their influence strongest?
17. Was the building of (democratic) legitimacy through the support from a social movement advantageous for technological development?

END

18. Finally, do you have anything that you feel I may be missing in relation to the role of institutions for technological innovation?
19. Are there any other people that you can think of that it might be interesting for me to speak to?

DEBRIEF:
How did you experience this interview? Etc.

8.5 QUESTIONNAIRE MAIN FIELDWORK

Name: **Date:**

Country: GER/UK, place: **Recording: Yes/No**

Type: **Rec No:**

The aim of this research is to explain why, despite having relatively similar rates of invention of new wind power technologies, Britain and Germany have followed significantly different trajectories of industrial development based on these new technologies. In particular I would like to understand the extent to which the different roles played by institutions in the two countries account for observed differences in the development of their respective wind power industries. Specifically I am interested in which interest groups were trying to influence institutional arrangements, how successful they were, and why.

In this research I am analysing the role of three types of institutions:

- Formal institutions: legal frameworks, rules and regulations, written documents
- Organisational forms of institutions: governments, local, regional, national, and quasi-governmental organisations.
- Informal institutions: cultural norms, values, attitudes amongst individuals, groups, society, regions or firms

INTRO

1. Please explain your own relationship to wind energy technology.

FORMAL INSTITUTIONS

Please describe the historical development of the wind energy industry in terms of the formal institutions (rules and regulations) that governed it.

2. How did formal rules and regulations favour or hinder the introduction and development of new wind power technologies?
3. From your perspective who were the key stakeholders in regulation for wind energy technology?
4. Who was getting involved in the creation of rules and regulations for wind energy technology and how?
5. Were smaller, civil society based agents and organisations effective in shaping policy? Why and how?
6. Were large businesses effective in shaping policy? Why and how?

ORGANISATIONAL FORMS OF INSTITUTIONS

Please describe the historical development of the wind energy industry in terms of the organisational forms of institutions (governmental and quasi-governmental bodies).

7. According to your knowledge, which were the most important governmental organisations in the area of wind energy technology?

8. How did these organisations directly and indirectly shape the development of wind energy technology?
9. Were these organisations open to influence from interest groups? To which groups in particular and why?
10. Were there individuals within these organisations that actively made decisions in favour or against wind energy technology? Can you give specific names?

INFORMAL INSTITUTIONS

Please describe the development of the wind energy industry in terms of informal institutions (norms, values, mindsets, beliefs).

11. From your perspective the prevalence or change of which attitudes or beliefs were most influential in the development of wind energy technology?
12. Did they help or hinder the creation of new wind energy technology? How?
13. How have these helped or hindered the further development of the technology?
14. How have the attitudes and beliefs changed over time and why?

END

15. Finally, do you have anything that you feel I may be missing in relation to any of the discussed institutions and their role for the wind energy industry?

Are there any other people that you can think of that it might be interesting for me to speak to?

8.6 LIST OF ABBREVIATIONS

BEE	Bundesverband Erneuerbare Energien
BWE	Bundesverband Windenergie
BWEA	British Wind Energy Association
CDU/CSU	Christlich Demokratische Union Deutschlands / Christlich-Soziale Union in Bayern e. V.
CEGB	Central Energy Generating Board
CEO	Chief Executive Officer
CME	Coordinated Market Economies
COP	Conference of the Parties
EEG	Erneuerbare Energien Gesetz
EREF	European Renewable Energies Federation
EU	European Union
EVS	European Values Study
EWEA	European Wind Energy Association
FDP	Freie Demokratische Partei
GER	Germany
GHG	Greenhouse Gas
GROWIAN	Große Windenergieanlage
GWEC	Global Wind Energy Council
HM	Her Majesty
IPCC	Intergovernmental Panel on Climate Change
IPR	Intellectual Property Rights
ISSP	International Social Survey Programme
LME	Liberal Market Economies
MLP	Multi-Level Perspective
NFFO	Non-Fossil-Fuel-Obligation
NIE	New Institutional Economics
OIE	Old Institutional Economics
RE	Renewable Energy
REA	Renewable Energy Association
RO	Renewables Obligation
SPD	Sozialdemokratische Partei Deutschlands
SPRU	Science Policy Research Unit
SPSS	Statistical Package for the Social Sciences

StrEG	Stromeinspeisungsgesetz
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VAWT	Vertical Axis Wind Turbine
VoC	Varieties of Capitalism
WREN	World Renewable Energy Network
WWEA	World Wind Energy Association

8.7 LIST OF INTERVIEWEES AND THEIR AFFILIATION

Code	Date	Place	Country	Affiliation
PG	Various	Various	GER	Interviews from previous study
P1	8 March 2012	unknown	UK	Interviews from previous study
P2	8 March 2012	unknown	UK	Interviews from previous study
P3	7 March 2012	unknown	UK	Interviews from previous study
P4	28 March 2012	unknown	UK	Interviews from previous study
P5	30 March 2012	unknown	UK	Interviews from previous study
A1	7 January 2015	Salzburg	GER	Academic who worked on the wind industry in Germany and UK
A2	15 January 2015	Reading	UK	Academic and inventor, former chair of BWEA
A3	9 February 2015	Aarhus/Skype	GER	Academic who worked on the wind industry in Denmark and Germany
A4	11 March 2015	Brighton	UK	Academic who worked on the wind industry in Germany and UK
A5	10 September 2015	Glasgow	UK	Academic and inventor who worked at Howden's
G1	22 June 2015	Paderborn	GER	Inventor, activist, former chair of BEE
G2	23 June 2015	Husum	GER	Mayoral function for the region of Nordfriesland
G3	23 June 2015	Husum	GER	Project leader for a body that coordinates industry and public sector in Schleswig Holstein
G4	24 June 2015	Berlin	GER	Government relations and leader of the Berlin office of ENERCON
G5	24 June 2015	Berlin	GER	Press officer BWE

Code	Date	Place	Country	Affiliation
G6	26 June 2015	Kiel	GER	President of GWEC, strong involved with regional banking sector, book author on wind energy industry in Germany
G7	13 August 2015	Freiburg/ Skype	GER	Executive for a regional electricity provider in the Freiburg area
G8	7 September 2015	Kuesten/ Skype	GER	Inventor, anti-nuclear activist and wind pioneer
G9	14 September 2015	Hamburg	GER	Certification professional, former Garrad Hassan employee, worked on GROWIAN as engineer
G10	16 September 2015	Husum	GER	President of WWEA
G11	16 September 2015	Husum	GER	Former civil servant, Green party member
G12	18 September 2015	Berlin	GER	Consultant Aurora Energiewende, former journalist, former environmental activist
G13	18 September 2015	Berlin	GER	Vice-president EREF, Board Member BEE, Green party, civil servant and RE champion
G14	29 September 2015	Kiel	GER	RE consultant, former civil servant in ministry for the environment
G15	1 October 2015	Hamburg/ Skype	GER	Vice president of offshore development at Senvion, started a wind co-operative in his community
G16	19 October 2015	Brussels/ Skype	GER	Lawyer with RE and community energy specialism, director at EREF, former civil servant at EU level
B1	30 July 2015	Stroud	UK	Engineer, innovator/entrepreneur, vice chairmen AEP, trustee and chairman WREN

Code	Date	Place	Country	Affiliation
B2	1 July 2015	London	UK	Inventor, former managing director at Wind Energy Group
B3	3 July 2015	Winchester	UK	Inventor, engineer at Wind Energy Group, offshore installation systems expert
B4	24 July 2015	Southampton	UK	Inventor, blade engineer, former WEG and Vestas, former CEGB
B5	28 July 2015	Bristol	UK	Wind pioneer, inventor, former engineer at WEG, founder of Garrad Hassan (now DNV-GL)
B6	28 July 2015	London	UK	Policy expert, formerly Scottish Power, now Natural Power
B7	5 August 2015	Haltwhistle/ Skype	UK	Developer on- and offshore, former civil servant, former chairman BWEA
B8	19 August 2015	London	UK	RE champion, former senior civil servant in Department of Energy under Thatcher
B9	2 September 2015	London	UK	RE consultant, former BWEA and REA chair
B10	3 September 2015	Kings Langley/ Skype	UK	CEO of RES Ltd, global developer, former VAWT Ltd
B11	4 September 2015	Virginia Water	UK	RE champion, former civil servant CEGB,
B12	10 September 2015	Glasgow	UK	Director of Innovation SGURR Energy, former Head of Innovation Scottish Power
B13	28 September 2015	Glasgow	UK	Inventor, former engineer at Howden's
B14	30 September 2015	London	UK	Deputy CEO of RenewableUK
B15	5 November 2015	Bristol/ Skype	UK	Wind engineer and certification expert at Garrad Hassan

8.8 CODING FRAME

Informal Institutions	Attitudes towards nuclear power	Positive attitude towards nuclear power
		Negative attitude towards nuclear power
	Attitudes towards renewable energy	Positive attitude towards renewable energy
		Negative attitude towards renewable energy
	Attitudes towards human made climate change	Human made climate change is real
		Human made climate change is not real
	Elitism	
	Care for the environment	Care for visual attributes mainly
		Care for endogenous resources
	Energy affordability	
	Energy security	
	Status of engineering	
Formal Institutions	Energy law	
	Tax law	
	Planning law	
	Finance and borrowing policies	Industrial support
		R&D funding
	Election system	
	Technical guidelines	
Organisational Forms of Institutions	Public bodies	Superordinate administration
		National administration
		Subnational administration
	Semi-public bodies	
	Pressure groups	
Technological Development	Path dependency	

	Path development	
	Technology diffusion	
	Technological lock-in	
	Break-out	
Institutional Development	Institutional stability	
	Institutional hysteresis	
	Institutional change	
Economic Development	Home market	
	Turbine industry	
	Regional economic development	
Forces	History	
	Culture	
	Variety of capitalism	
	Media bias	
Agents	Civil society agents	Citizens, users, consumers
		Inventors, innovators, entrepreneurs
		Activists
	Policymakers	Professional politicians
		Other civil servants
	Economic landscape agents	Banks – large
		Banks – regional
		Enterprise – large
		Enterprise – small and medium
		Industry – Construction
		Industry – Manufacturing
		Industry – Service
		Provider – nationalised
		Provider - privatised
Agents' Strategies	Political strategies	
	Lobbying	

	Industrial strategy	
Effect	Barrier	
	Facilitator	
Timings	1945 – 1980	
	1981 – 1990	
	1991 – 2000	
	2001 – 2010	
	2011 - now	
Other	Quotes	
	Signposts	